AL-TR-1991-0082

AD-A246 934

ARMSTRONG LABORATORY

ERGONOMICS MANUAL

Judith A. Holl, Major, USAF, BSC

OCCUPATIONAL AND ENVIRONMENTAL
HEALTH DIRECTORATE
Brooks Air Force Base, TX 78235-5000

October 1991

Final Report

Approved for public release; distribution is unlimited.

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235-5000

NOTICES

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely Government-related procurement, the United States Government incurs no responsibility or any obligation whatsoever. The fact that the Government may have formulated or in any way supplied the said drawings, specifiications, or other data, is not to be regarded by implication, or otherwise in any manner construed, as licensing the holder or any other person or corporation; or as conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

The mention of trade names or commercial products in this publication is for illustration purposes and does not constitute endorsement or recommendation for use by the United States Air Force.

The Office of Public Affairs has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.

Government agencies and their contractors registered with Defense Technical Information Center (DTIC) should direct requests for copies to: DTIC, Cameron Station, Alexandria VA 22304-6145.

Non-Government agencies may purchase copies of this report from: National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield VA 22161.

Judith A Holl

JUDITH A. HOLL, Major, USAF, BSC
Chief, Health Surveillance Function

Mark H Stokes

MARK H. STOKES, Colonel, USAF, BSC
Deputy Chief, Occ Med Division

REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
October 1991

3. REPORT TYPE AND DATES COVERED
Final

4. TITLE AND SUBTITLE
Ergonomics Manual

5. FUNDING NUMBERS

6. AUTHOR(S)
Judith A. Holl

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Armstrong Laboratory
Occupational and Environmental Health Directorate
Brooks Air Force Base, TX 78235-5000

8. PERFORMING ORGANIZATION REPORT NUMBER
AL-TR-1991-0082

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This report is written to assist base-level aerospace medicine services personnel establish a program for identifying and correcting ergonomic deficiencies in workplaces on their bases. It is provided as a starting point for assembling information and learning about ergonomics. A suggested bibliography is included that will help establish reference libraries. This report is not an all inclusive reference, but highlights major areas of ergonomics. More detailed texts should be used for indepth information.

14. SUBJECT TERMS
Ergonomics, Cumulative Trauma Disorders, Overexertion Injuries

15. NUMBER OF PAGES
104

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev 2-89)
Prescribed by ANSI Std Z39-18
298-102

CONTENTS

Page

APPENDIXES

List of Figures

Fig. No.

List of Tables

Table No.

ERGONOMICS MANUAL

INTRODUCTION

Purpose

This technical report will help Environmental Health Officers (EHOs), Bioenvironmental Engineers (BEEs), and other Aerospace Medicine (ASM) personnel establish and manage base-level programs targeting ergonomic problems in the workplace.

Scope

Ergonomics is a relatively recent concept to be applied to United States Air Force (USAF) industrial and administrative work areas. This report defines the problem and provides basic information to establish a base-level program.

DISCUSSION

Definition

The term "ergonomics" was used after World War II by a group of physical and biological scientists in the United Kingdom to describe their activities which were emerging as a result of problems encountered from wartime technology. The word is derived from two Greek words, ergo = work and nomos = laws.

Ergonomics includes the study of physiological responses to physically demanding work; environmental stressors such as heat, noise, and illumination; complex psychomotor assembly tasks; and visual monitoring tasks. The emphasis is on reducing fatigue by designing tasks within people's capabilities (3). Ergonomics is an interdisciplinary science that brings together engineering and medicine to analyze the interaction between people and the work environment.

Several principles are fundamental to ergonomics:

1. The human body has limitations which should be considered in the design of any tool, workplace, or product.

2. Individuals possess different limitations. Good design takes into consideration the diversity of potential users.

3. Musculoskeletal injury is possible when human capabilities are exceeded (4).

The concept of ergonomics in industrial and administrative settings involves designing work areas and job processes for the individual worker. The goals are to decrease cumulative trauma disorders (CTDs) and other musculoskeletal injuries and to increase productivity in the workplace. The rising incidence of these illnesses and injuries and the ensuing costs are outlined in the following section.

Need for Ergonomics Program

Several factors account for the need to emphasize ergonomics, including the increase in reported musculoskeletal injuries and illnesses, the rising costs of these disorders, the changing demographics of the work force, and work environments.

Rising Incidence of Musculoskeletal Injuries/Illnesses

The Bureau of Labor Statistics reports that more than 50% of all occupational illnesses reported in 1990 were associated with CTDs.

The National Institute for Occupational Safety and Health (NIOSH) estimates that 5 million Americans suffer from CTDs; by the year 2000, 50% of workplaces will be at risk for causing these disorders.

CTDs account for more than 16 million workdays lost per year by employees.

Rising Costs

The Occupational Safety and Health Administration's top expert on industrial engineering and ergonomics states that up to 40% of workers' compensation awards are for "soft tissue disorders"--back injuries, carpal tunnel syndrome (CTS), and tendonitis.

Musculoskeletal injuries, including cumulative trauma disorders, are estimated to cost employers $40 billion a year.

Carpal Tunnel Syndrome alone affects at least 23,000 workers a year; estimated cost per person in benefits and rehabilitation--$3,500.

Changing Demographics

The change in demographics of the work force is a pronounced factor in ergonomics. The work force is aging. By the year 2050, one-third of the U.S. population will be at least 55 years old. Older workers have decreased muscle performance, flexibility and joint mobility. The current and future work force is more diverse. Young women and immigrants are entering the work force in greater numbers. These groups are generally smaller in stature than workers in the past (6).

Changing Work Environments

New technologies have made work physically taxing in new ways. Industry shifts to faster forms of automation have caused tasks to be specialized to the extreme. Workers may have to perform the same single-step thousands of times in any workday. Prior to automation the worker would perform a range of motions to perform the job. For the office worker, computers and word processors have eliminated the need to perform a range of tasks. As a result, the worker at a computer or video display terminal (VDT) may perform 23,000 keystrokes in a single work period with no rest period (1).

Ergonomic Deficiencies

Ergonomic deficiencies are situations in the workplace which over time will adversely affect human health. These situations are characterized by a number of recognizable manifestations: extreme posture, excessive force, concentration of stress, and static loading. These manifestations are considered early warnings to ergonomic deficiencies; another two, pain and/or discomfort and high incidence of occupational disorders, are the final outcomes that happen when deficiencies are not identified and corrected.

Extreme Posture

Posture refers to the alignment of body segments. Placing one or more body segments in an extreme position out of alignment with other segments will produce extreme posture. Generally, any posture that does not look right or appears difficult to maintain reliably can be called extreme.

Causes include:

1. Improper reach, arms fully extended--above shoulder or below the waist.

2. Improperly designed tools and machine controls--too bulky to hold or difficult to reach without adopting an extreme position.

Excessive Force

Material handling and the use of hand and power tools requires the worker to exert force. The force required depends on the weight and bulk of the object as well as body posture. The worker exerts force to overcome mechanical disadvantage of maneuvering bulky, heavy objects while in an awkward position.

Concentration of Stress

Stress is a force divided by the area over which it is applied. The larger the area to which the force is applied, the less the stress, and vice versa. From the human body perspective, the fewer muscles used to deliver the force, the higher the stress placed on the body. Repetitive jobs using short and fast motions are inclined to concentrate the stress.

Time is an important factor in determining stress concentration. Stress applied infrequently should not be as harmful as stress occurring throughout the day.

Static Loading

This term is used to describe situations where body segments are motionless or prevented from changing positions. Inability to change positions causes muscle fatigue and decreases blood flow. If the muscle is not allowed to relax, the demand for nutrients (glucose and oxygen) exceeds the supply. With decreased blood supply, the removal of the waste products of muscle metabolism is decreased. If this restriction occurs on a routine basis, the muscle will lose its ability to contract. If this restriction is allowed to continue over a long period, deterioration can take place in joints, tendons and ligaments.

Consequences of Ergonomic Deficiencies

Frequent complaints of fatigue, discomfort, and pain are indications that ergonomic deficiencies may be present.

Rise in Workman's Compensation claims for musculoskeletal disorders and an increase in lost work time are indicators that ergonomic problems may be occurring.

Decrease in job performance and productivity may be observed and be a cause of low morale.

High rate of turnover or transfers from certain jobs may point out high-risk areas.

MUSCULOSKELETAL DISORDERS
(Overexertion Disorders)

Overexertion disorders, such as low back pain, tendonitis and carpal tunnel syndrome, are the leading cause of work-related disabilities and Workman's Compensation costs in the United States and other industrialized nations (8).

Six generic categories of ergonomic risk factors are found in a wide range of industrial jcbs:

1. Forceful exertions.
2. Awkward work postures.
3. Repetitive motions.
4. Localized contact stresses.
5. Whole body or segmental vibration.
6. Temperature extremes.

Cumulative Trauma Disorders

Definition

Cumulative trauma disorders are defined as painful and limiting soft tissue failures that result from repeated or continuous application of slight to moderate physical stress over extended periods of time. The result is often damage to the muscles, tendons, joint surfaces, nerves, or other soft tissues (2).

Contributing Factors

Contributing factors are worker fatigue from lack of rest or because they are recovering from an illness. This fatigue may occur if a person is required to perform work that exceeds the capacity for physical exertion at the time.

When high repetition is combined with forceful and awkward postures and there is insufficient recovery time, the worker is at risk for developing a CTD.

Process of CTD Development (2)

Stage 1: Pain during the work shift.
No change in work capacity.
No physical signs.
Symptoms reversible within 1 month.

Stage 2: Pain during sleep.
Reduced work capacity.
Physical signs possible.
Condition persists for months.

Stage 3: Pain even with light work and nonrepetitive motion.
Leisure activities affected.
Physical signs present.
Symptoms persist for months or years.

CTDs of the Upper Extremities

Anatomically, there are three basic types of injuries to the arm: tendon disorders, nerve disorders, and neurovascular disorders.

Tendon Disorders

Tendonitis: inflammation that occurs when the muscle/tendon unit is repeatedly tensed. Injured tendons may tear apart or become thickened and irregular and without sufficient time to heal may be permanently weakened.

Tenosynovitis: repetitively induced injury involving the synovial sheath. Extreme repetition causes the sheath to produce excessive amounts of synovial fluid. The excess fluid accumulates and the area becomes swollen and painful.

De Quervain's disease: stenosing tenosynovitis affecting the tendons on the side of the wrist and at the base of the thumb. Forceful gripping can be a cause for this disorder.

Trigger finger: when the tendon sheath of a finger is sufficiently swollen so that the tendon becomes locked in the sheath. Attempts to move that finger will cause a jerking motion. This condition is associated with the use of tools with hard or sharp handles.

Ganglionic cyst: the tendon sheath swells with synovial fluid and causes a bump under the skin, usually on the wrist.

Unsheathed tendons: found in the elbow and shoulder joints.

The most common disorder in this area is termed "tennis elbow" or lateral epicondylitis. Caused by overuse of the tendons of the forearm, pain radiates from the elbow down the forearm.

Rotator cuff tendonitis or bursitis: the rotator cuff consists of four tendons that fuse over the joint to provide stability and mobility to the shoulder. Work that requires the elbow to be elevated and puts stress on the shoulder tendons causes this disorder.

Nerve Disorders

Carpal Tunnel Syndrome (CTS): tendons for flexing the fingers, the median nerve, and blood vessels all pass through the carpal tunnel, leading from the forearm to the hand (Fig. 1). If any of the tendon sheaths become swollen in the small area of the carpal tunnel, the median nerve may be pinched. Pressure on, or compression of, the median nerve can occur from chronic irritation of the tendons of the wrist. This pressure interferes with normal sensations felt on the palm and back areas of the hand, especially the first three fingers and base of the thumb.

Diagnostic techniques for the detection of CTS in an occupational surveillance population are few, and some are not precise. Nerve conduction studies are the gold standard for evaluation; however, the test is not suitable for surveillance of large populations and is expensive to conduct. The Phalen sign is a noninvasive diagnostic test that is performed with the dorsal aspects of both flexed wrists in apposition for 60 s and is considered positive if pain or paresthesia occurs in one of the first three digits. Tinel sign is another noninvasive test that is done by dropping the square end of a reflex hammer on the distal wrist crease and is considered positive if at least one of the first three digits has pain or paresthesia. Both these non-invasive tests if done in conjunction with a good history and questionnaire have a low positive predictive value (0.50). In other words, the combination of tests and history would only identify half of the true positive CTS cases in an occupational surveillance population (7). Individual cases of suspected CTS should be confirmed by nerve conduction prior to having a confirmed diagnosis of CTS.

Neurovascular Disorders

Thoracic Outlet Syndrome: compression of the nerves and blood vessels between the neck and shoulder. The symptoms can be similar to CTS with numbness in the fingers of the hand, the arm may feel as if it is falling asleep, and the pulse at the wrist may be weakened. If circulation is decreased by activities or postures that put excessive pressure on these blood vessels, the adjacent tendons, ligaments, and muscles will be deprived of oxygen and nutrients. This ischemic condition will limit muscle activity and recovery.

Vibration Syndrome/White Finger/Raynaud's Phenomenon: recurrent episodes of finger blanching due to complete closure of the digital arteries. Vasospasm in the fingers may be aggravated by exposure to cold. Symptoms include intermittent numbness and tingling in the fingers, skin turns pale and cold, and eventual loss of sensation and control in the fingers and hands. Causes are forceful gripping and prolonged use of vibrating tools such as power grinders, riveters, and pneumatic hammers.

Treatment and Rehabilitation for CTDs

Several treatment options may be helpful in relieving symptoms and restoring function (2):

Time Off from Primary Job: this approach is most useful in Stage 1 of the Process of CTD Development, when damage is easily reversed. Without job modifications to prevent further damage, rest does not guarantee long-term improvement.

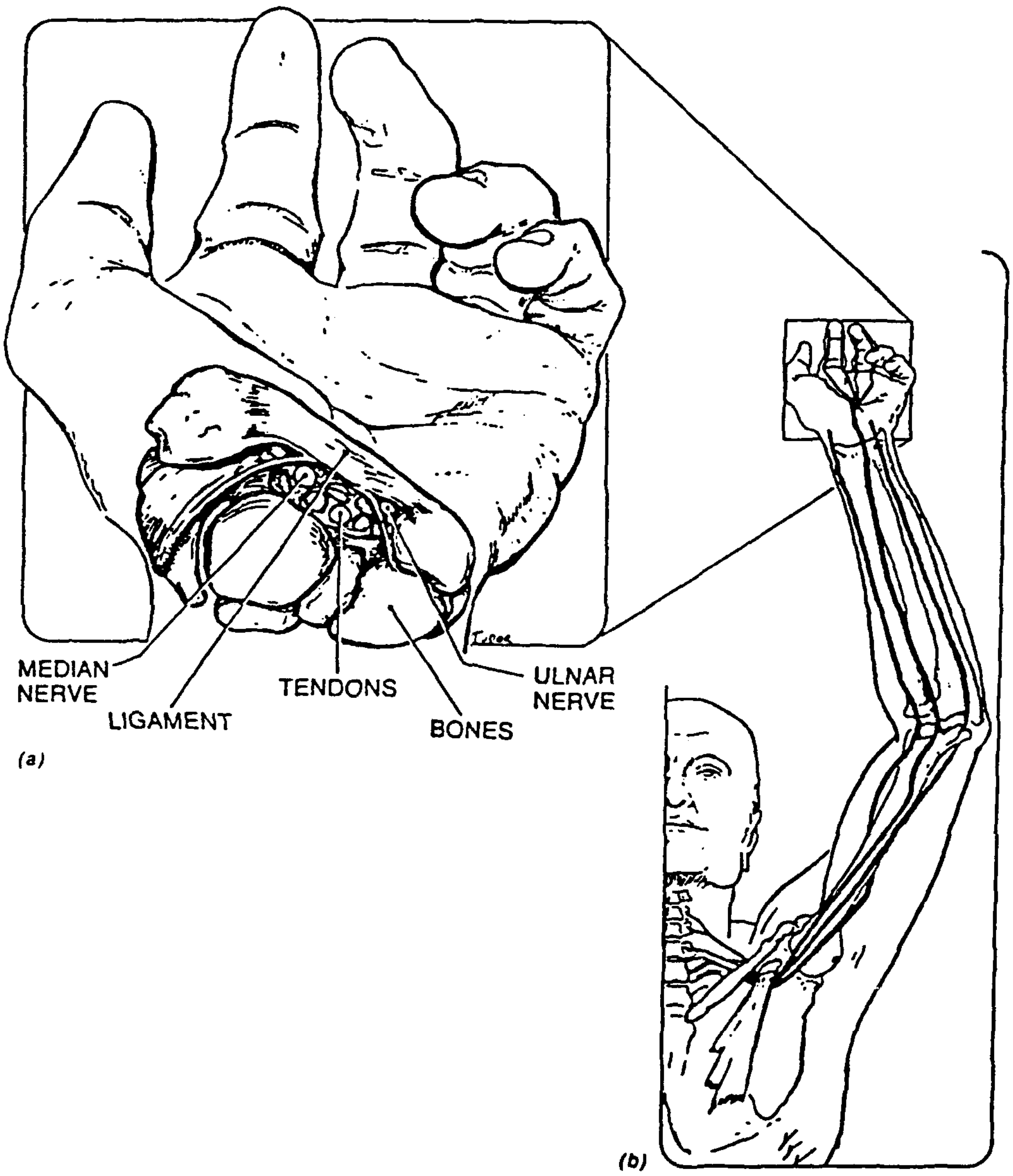
Splints and Supports: helps workers through the acute stage by restricting movement and loading. Splints and supports may be effective if fitted and used properly but can introduce new problems as well as impair performance. For example, workers may subconsciously make an effort to overcome the splint's effect. If splints are used, exercises should be done to prevent stiffening of the affected joint.

Physical Therapy: when the damage progresses to musculoskeletal weakness, appropriate physical therapy provides the most benefit, strengthening the worker. However, with entrapment neuropathies like CTS, exercise may aggravate the problem.

Drug Therapy: administration of drug therapies is considered controversial; long-term therapy does have some risks. Examples of drug remedies include analgesics, antiinflammatories, steroids, muscle relaxants, diuretics, local anesthetics, and vitamin B.

Surgery: some CTDs, such as CTS, respond well to surgery if the worker does not respond to other more conservative therapies. Generally, back problems are difficult to treat, even with surgery.

Return-to-Work Evaluations: an evaluation of the worker should be done prior to return to the job. This evaluation should be a physical assessment of the worker, which is compared to the biomechanical requirements of the job.



Reprinted, by permission from Vern Putz-Anderson, "Cumulative Trauma Disorders," 13.

Figure 1. a. Cross section of the wrist showing the carpal tunnel that serves as a passage for finger tendons and the median nerve.

b. Pathway traced by three major nerves that originate in the neck and feed into the arm and hand: ulnar, median, and radial.

Musculoskeletal Diseases of the Back

Unless otherwise cited, the following information in this section on back disorders is taken from the NIOSH Work Practices Guide for Manual Lifting, March 1981 (10). NIOSH is updating this Guide; however, it was not available at time of publication.

Back Pain

Back pain is seldom well localized. When severe, back pain may be referred down the buttocks and thighs without root involvement. It cannot be measured since the severity of pain experienced has no direct relationship to the underlying pathological process. An accurate identification of the site and origin of the pain is not easy; X rays are typically not useful. The pain can be defined as primary or secondary.

Primary: arises directly from the tissues of the back which are in a state of neurological, mechanical or biochemical irritation because of fatigue, postural stress, injury or local pathological change such as degeneration.

Secondary: caused by a lesion which affects the nerve supply to the tissues of the back. For example, degenerative processes affecting the discs.

Factors Related to Back Pain

No single factor can be ascribed to the etiology of back pain. Possible contributory factors include:

- Fatigue
- Postural stress
- Trauma
- Socioeconomic and emotional stress
- Personality
- Degenerative changes
- Congenital defects
- Reduction in the size and shape of the spinal canal
- Genetic factors
- Stretching, compression or adhesion of nerve roots
- Neurological dysfunction
- Duration of symptoms
- Physical fitness
- Body awareness

This list is not complete and does not convey the complexity of the problem which is compounded by the way these contributory factors interact.

Job Risk Factors

Several aspects of the act of manually lifting are identified as potentially harmful to a worker's musculoskeletal system:

Weight - force required. It is the most obvious factor which affects risk for injury. The frequency of low-back injuries is greater in "heavy" versus "light" industries.

Location/Site - position of the load center of gravity with respect to the worker's spinal column. The physical dimensions of the load are important from a biomechanical perspective.

Frequency/Duration/Pace - time aspect of the task in terms of repetitiveness of handling. Repetitive lifting can cause "wear and tear" in connective tissues, a greater potential for muscle fatigue, and a greater probability of an uncoordinated muscle action during a lift.

Stability - consistency in location of load center of gravity.

Coupling - texture, handle size and location, shape, etc., of container.

Workplace Geometry - spatial aspects of the task in terms of movement distance, direction, postural constraints, etc.

Environment - temperature, humidity, illumination, noise, vibration, frictional stability of the foot, etc.

Personal Risk Factors

The capacity to perform the physical act of lifting varies not only from individual to individual, but also within any given person over time.

Gender - a woman's lifting strengths, primary arms and torso, on the average, are about 60% of a man's. However, the range in strength of both males and females is large, so, gender, becomes secondary to the strength factor.

Age - has a complex effect on the many factors that in combination influence workers to safely handle heavy loads. In general, advanced age often is used to restrict a person from load handling jobs.

Anthropometry - body weight and stature are two attributes which influence a worker's risk for injury. Weight has a direct effect on energy expenditure; a heavier person would have a greater metabolic rate which could lead to earlier fatigue. Otherwise, the heavier person has the mass necessary to counter-balance the handling of large objects and is usually stronger than a lighter person.

Lift Technique - an individual worker's technique for minimizing injury. It is a controversial subject whether any one technique decreases the incidence of back injury. It may be safer to allow workers to decide using their own experience and body sense, instead of teaching them new drills where predetermined positions must be consciously assumed.

Biomechanics of Load Handling

The stresses induced at the low back during manual materials handling are due to a combination of the weight lifted and the individual's method for lifting. The load held in the hands together with the individual's body masses (when acted on by gravity) create rotational moments or torques at the various joints of the body. The muscles are positioned to exert forces at these joints so that they counteract the torques due to the load and body weight.

For example, when a 20 kg (44 lb) load is held at arm's length it produces a large torque at the lumbosacral joint of the back. For the average man's anthropometry, this load produces more than a 1,200 kg-cm torque. In combination with the torso weight, this produces a compression force at the L5/S1 disc equivalent to what holding about a 40 kg (88 lb) load between the knees would produce. This example demonstrates that a person does not need to bend over to produce high torque forces on the low back.

Several general biomechanical concepts:

1. Bring the load as close to the torso's center of gravity as possible.

2. When possible, keep the load as close to or between the knees, lift with the legs keeping the back in a vertical position ("squat lift"); however, this must be qualified. Many people are not capable of lifting in this manner because they do not possess the quadricep strength necessary to extend the knees and raise the body from such a position.

3. The lifting method that instructs bending at the waist to reach a load located on or near the floor, or "stooped-over lift," may be appropriate when lifting large objects that cannot pass between the knees.

4. Whenever possible, loads should be reduced in size to allow them to pass between the knees.

5. Lifting instructions for lifting postures must take into consideration the person's strength and mobility as well as the weight, size, and location of the load.

WORKPLACE SURVEYS AND JOB ANALYSIS

Initial Evaluation of the Problem

Some estimate is needed of the nature and incidence of the declared health problems on the base. Reviewing the AF Forms 190, Occupational Illness and Injury Report, requesting information on numbers and locations of back injuries from the Base Safety Office and reviewing Workman's Compensation claim forms, CA-1s and CA-2s, from the Civilian Personnel Office will help identify workplaces that have documented musculoskeletal illnesses and injuries. Once this task is accomplished, workplaces on base can be prioritized for detailed job analysis.

Another alternative to identifying workplaces with potential ergonomic problems is to combine an ergonomic survey with BEE routine annual shop industrial hygiene surveys and walk-throughs. This alternative cannot be used with administrative areas since routine BEE surveys are not done on these areas. Reviewing these reported case records and responding to individual complaints are the initial means of targeting administrative areas.

Administering questionnaires to the workers that may identify new or preclinical cases of musculoskeletal diseases may be useful (Appendix A). A body part discomfort form (Appendix A) can be used to help pinpoint target areas of the body.

Once high-risk workplaces are identified and specific job tasks singled out, the ergonomic team composed of the BEE, EHO, and flight surgeon/ occupational medicine physician should do a detailed analysis of the job. Base Safety should be given the opportunity to participate.

Job Analysis

The purpose of the job analysis is to determine the relationship between work patterns and musculoskeletal impairment. Workplace checklists that itemize risk factors for musculoskeletal disorders are useful.

The use of videotaping is suggested for the analysis of the work process. In this way the task can be viewed in slow motion to determine the demands of the job on the worker, and unnoticed detail is easier to identify in slow motion.

Typically three major areas are analyzed: work methods, workstation design and worker posture, and tool design.

Analysis of Work Methods

Determine what the worker must do to perform the task successfully.

1. This analysis may require recording arm and hand positions, computing the number of repetitive movements in a work cycle, and estimating (or measuring) the forces required by the job.

2. Note the organization of the work with duration of a task cycle. The amount of time an extremity is maintained in a certain stressful posture is important.

3. The speed, intensity, and pace at which the worker must perform to meet production standards should also be noted.

4. Lifting Analysis

Calculating Load Limits: NIOSH's Work Practices Guide for Manual Lifting, March 1981 (10), Chapter 8 outlines load limit guidelines for lifting tasks. This guide contains the definitions and formulas needed to calculate maximum loads. The chapter is reproduced in Appendix B as a convenience to base-level users that may find it difficult to obtain the entire Work Practices Guide. NIOSH is currently working on a new edition of this guide that is significantly different.

Lifting Model: Another method of analyzing lifting loads is by comparing actual weights of loads lifted to acceptable weight of lift tables (10).

Dynamic Strength Models have been developed using the manual handling studies summarized by Stover H. Snook in 1978 (12). The maximum acceptable weights for lifting tasks are in Table 1 for male industrial workers and female industrial workers. These values are based on a freely chosen lifting posture where workers are not instructed to lift by any particular technique. NOTE: "Width" for the data in the tables means distance of the load away from the body measured from the horizontal axis (midpoint of the body).

Analysis of the Workstation

The relationships between the worker and workstation features, such as sitting versus standing, and other postural factors are analyzed.

1. Static work: discomfort and fatigue may arise from having to hold tensed muscles in a fixed or awkward position for long periods.

2. Workspace and reaching distance: most workstations are not designed to fit a wide range of size and weight of the people using them and are not adjustable. The goal of a workstation design should be to establish reach limits allowing objects to be grasped without excessive body motion or energy expenditure.

3. Height of the workstation: ideal surface height is a function of both the elbow height of the worker and the type of work. Elbow height is determined with the elbows held close to the body and bent 90 degrees (Fig. 2).

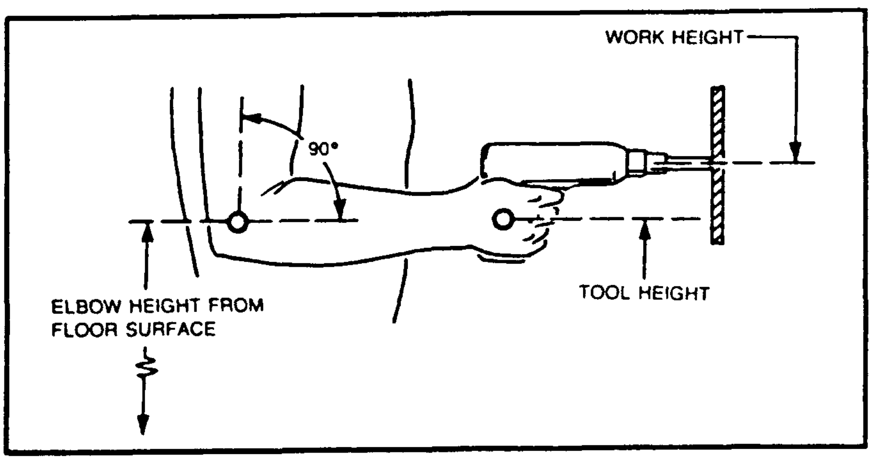


Figure 2. Elbow height determination.

Reprinted, by permission from Vern Putz-Anderson, "Cumulative Trauma Disorders," 64.

TABLE 1. ACCEPTABLE LIFTING WEIGHTS

Maximum acceptable weight of lift for males (kg) (Snook, 1978)

Width (a)	Distance (b)	Percent (c)	Floor to knuckle ht. One lift every 5 s	9 s	14 s	1 min	5 min	8 h	Knuckle to shoulder ht. One lift every 5 s	9 s	14 s	1 min	5 min	8 h	Shoulder to arm ht. One lift every 5 s	9 s	14 s	1 min	5 min	8 h
		75	10	14	15	18	25	22	12	16	18	[illegible]	21	[illegible]	9	12	14	16	20	23
	76	50	13	17	19	22	30	36	14	19	21	21	27	30	11	15	18	20	25	28
		25	16	20	23	26	36	42	17	22	25	26	32	36	13	18	21	24	29	33
		75	11	14	16	19	26	31	13	17	19	20	24	27	10	14	15	18	22	25
75	51	50	14	18	20	23	31	37	15	20	23	24	30	34	12	17	10	22	28	31
		25	16	21	24	27	37	44	18	24	27	29	36	40	14	20	23	27	33	37
		75	13	17	19	21	29	34	15	20	22	23	28	32	11	16	18	21	26	30
	25	50	16	21	23	26	35	42	18	24	27	28	35	40	14	20	22	26	33	37
		25	19	25	28	31	42	50	21	28	32	34	42	47	17	24	27	31	39	44
		75	12	15	17	21	28	34	12	16	18	17	21	24	9	12	14	16	20	23
	76	50	15	19	21	26	35	42	14	19	21	21	27	30	11	15	18	20	25	28
		25	17	23	26	31	42	50	17	22	25	26	32	36	13	18	21	24	29	33
		75	12	16	18	22	30	35	13	17	19	20	24	27	10	14	15	18	22	25
49	51	50	15	20	22	27	37	43	15	20	23	24	30	34	12	17	19	22	28	31
		25	18	24	27	32	44	52	18	24	27	20	36	40	14	20	23	27	33	37
		75	14	18	21	24	33	39	15	20	22	23	28	32	11	16	18	21	25	30
	25	50	18	23	26	30	41	49	18	24	27	28	35	40	14	20	22	26	33	37
		25	21	28	31	36	49	59	21	28	32	34	42	47	17	24	27	31	39	44
		75	13	17	20	23	31	37	13	17	19	18	23	26	9	13	15	17	21	24
	76	50	17	22	25	29	39	46	15	20	23	23	29	32	11	16	19	21	27	30
		25	20	27	30	34	47	55	18	23	26	28	34	39	14	19	23	26	32	36
		75	14	18	20	24	32	38	[illegible]	18	20	21	26	29	10	15	16	19	24	27
36	51	50	17	23	26	30	40	48	16	21	24	26	32	36	13	18	20	24	30	34
		25	21	28	31	36	49	57	19	25	28	31	39	44	15	22	25	29	36	40
		75	16	21	24	27	37	43	16	21	24	24	30	34	12	17	19	23	28	32
	25	50	20	27	30	34	46	54	19	25	28	31	38	43	15	22	24	28	35	40
		25	25	32	36	40	55	65	22	29	33	37	45	51	18	26	29	34	42	48

Maximum acceptable weight of lift for females (kg) (Snook, 1978)

Width (a)	Distance (b)	Percent (c)	Floor to knuckle ht. One lift every 5 s	9 s	14 s	1 min	5 min	8 h	Knuckle to shoulder ht One lift every 5 s	9 s	14 s	1 min	5 min	8 h	Shoulder to arm ht. One lift every 5 s	9 s	14 s	1 min	5 min	8 h
		75	8	10	11	13	17	20	8	11	11	11	14	15	5	9	9	10	12	14
	76	50	9	12	13	14	20	23	9	12	12	13	16	18	6	9	10	11	13	15
		25	10	13	15	16	22	26	10	13	13	14	18	20	6	10	11	12	15	17
		75	8	10	12	13	18	21	9	12	12	12	15	17	6	10	11	11	14	15
75	51	50	9	12	14	15	20	24	10	13	13	14	18	20	6	11	12	12	15	17
		25	10	14	15	17	23	27	11	14	14	16	20	22	7	12	13	13	17	19
		75	9	12	14	15	20	24	11	14	14	15	18	20	7	11	13	13	16	18
	25	50	11	14	16	17	23	27	12	15	15	17	21	23	8	13	14	14	18	20
		25	12	16	18	19	26	31	13	17	17	19	23	26	8	14	15	16	20	22
		75	9	11	13	15	20	24	8	11	11	11	14	15	5	9	9	10	12	14
	76	50	10	13	15	17	23	27	9	12	12	13	16	18	6	9	10	11	13	15
		25	11	15	17	19	26	31	10	[illegible]	13	14	18	20	6	10	11	12	15	17
		75	9	12	13	15	21	25	9	12	12	12	15	17	6	10	11	11	14	15
49	51	50	10	13	15	17	24	28	10	13	13	14	18	20	6	11	12	12	15	17
		25	12	15	17	20	27	32	11	14	14	16	20	22	7	12	13	13	17	19
		75	10	14	15	17	23	28	11	14	14	15	18	20	7	11	13	13	16	18
	25	50	12	16	18	20	27	32	12	15	15	17	21	23	8	13	14	14	18	20
		25	14	18	20	22	30	36	13	17	17	19	23	26	8	14	15	16	20	22
		75	10	13	14	16	22	26	9	12	12	12	14	17	6	9	10	11	13	15
	76	50	11	15	17	19	25	30	10	13	13	14	17	19	6	10	11	12	15	16
		25	13	17	19	21	28	34	11	14	14	15	19	21	7	11	12	13	16	18
		75	10	13	15	17	23	27	9	12	12	13	17	19	6	10	11	12	15	17
36	51	50	12	16	17	19	26	31	10	14	14	15	19	21	7	11	13	13	16	18
		25	14	18	20	22	30	35	11	15	15	17	21	24	8	12	14	14	18	20
		75	12	16	18	19	26	31	11	15	15	16	19	22	8	12	14	14	17	20
	25	50	14	18	20	22	30	35	12	16	16	18	22	25	8	14	15	16	19	22
		25	16	21	23	25	33	40	13	18	18	20	25	29	9	15	16	17	21	24

(a) Width of object (cm) Note: horizontal hand location is at least (15 + width/2).
(b) Vertical distance of lift (cm)
(c) Percent of industrial population exceeding table value

Analysis of Handle and Tool Designs

Tools that are poorly designed for the worker and job may have a number of undesirable characteristics, including an awkward grip, a handle that causes the wrist to bend, a trigger requiring heavy pressure, a lack of balance, and low-frequency vibration.

Indicators of faulty tool selection or usage: examination of body postures and work conditions may reveal that an inappropriate tool is being used.

Examples of such conditions:

1. Static loading of arm and shoulder muscles.

2. Awkward hand position, especially wrist deviation.

3. Excessive or continuous pressure on the palm and fingers.

4. Exposure to cold and vibration from power tools.

5. Pinch points with double-handled tools.

6. Handles that require stretching of the hand to grip of high force to hold.

Tool-induced Postures: the location of the handle may cause the worker to bend the wrist to use the tool (Fig. 3). Ulnar deviation (bending the wrist toward the little finger) may be caused by using the wrong shaped tool on a surface that is either too high or low (Fig. 4). Radial deviation of the wrist can lead to epicondylitis due to increased pressure between the head of the radius and the humerus in the elbow.

Tool-related Repetitive Action: repetitive finger motion required to operate triggers on tools may lead to "trigger finger." This phenomenon is associated with the use of tools with handles too large for the worker's hand.

PREVENTION OF MUSCULOSKELETAL DISORDERS

The following discussions of controls are overviews of possible solutions. This manual is not inclusive of all alternatives and it does not contain in-depth information. Comprehensive information is available from several recommended references located in Appendix C.

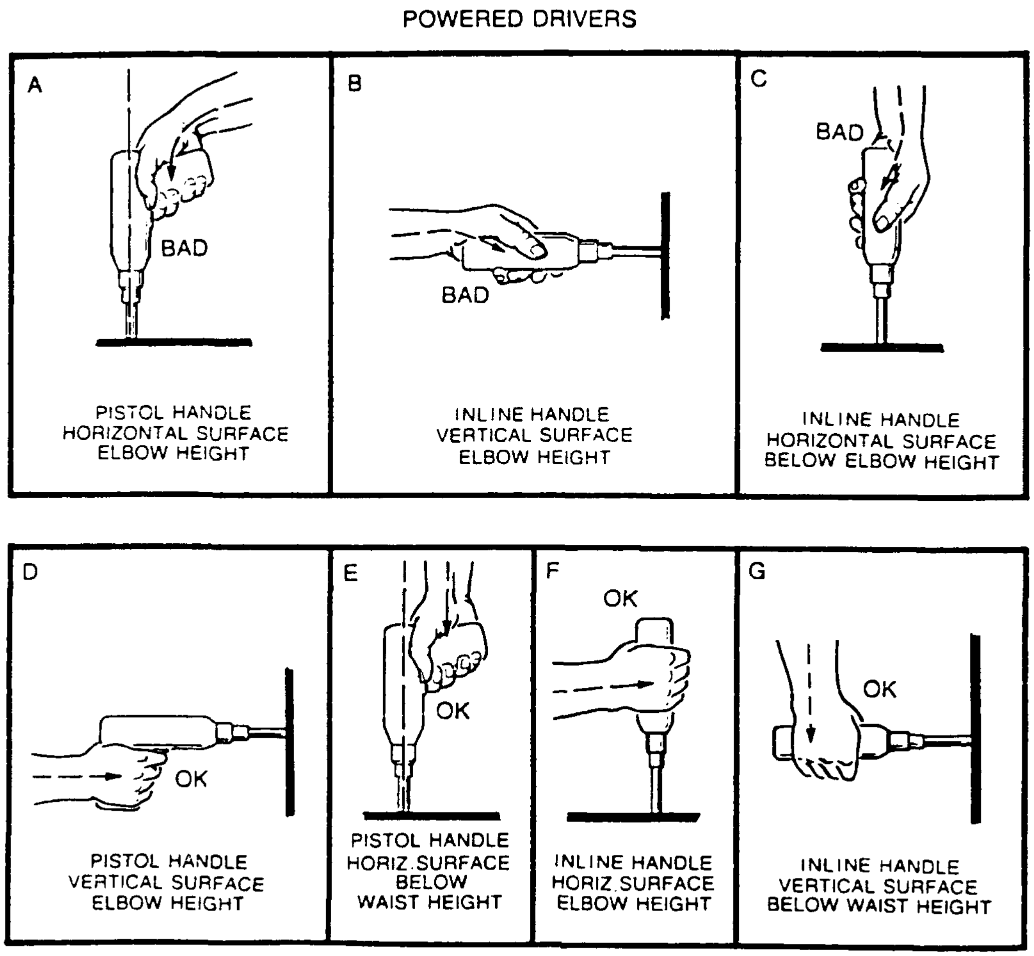


Figure 3. Examples of wrist postures used with various hand tools.

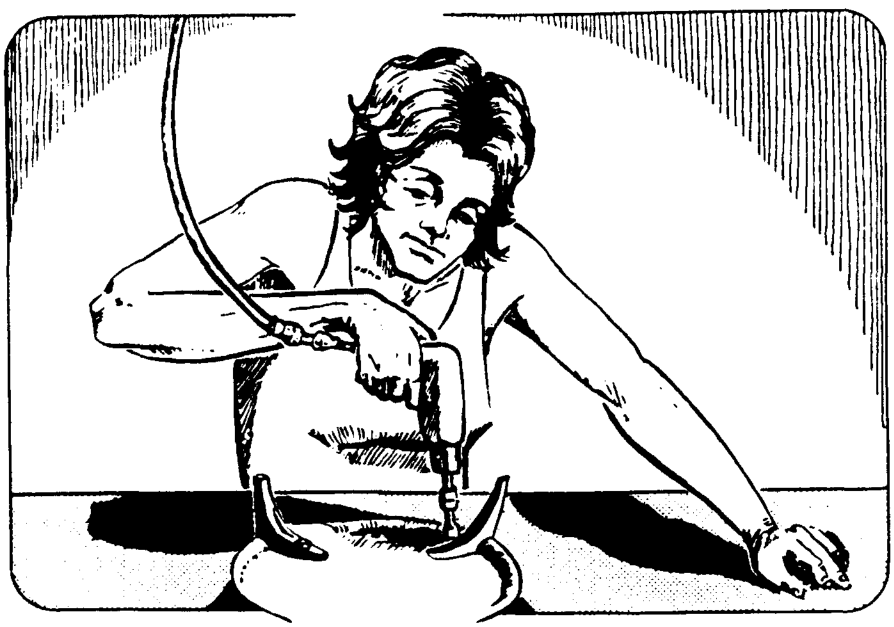


Figure 4. Ulnar deviation associated with faulty tool and workstation layout.

Reprinted, by permission from Vern Putz-Anderson, "Cumulative Trauma Disorders," 106;67.

Administrative Controls

Administrative controls refer to actions taken by management or medical staff to limit the potentially harmful effects of a physically stressful job on individual workers. Administrative controls modify existing personnel functions, such as:

1. Worker training.

2. Job rotation.

3. Selecting workers to fit specific jobs.

Worker Training

Teaching workers to work efficiently in a safe and healthful manner usually involves training aimed at reducing the number and types of awkward wrist, arm, and shoulder postures; minimizing the mechanical forces applied; reducing the number of repetitive motions; and safe lifting practices to include recognizing hazardous loads and positions.

Cumulative Trauma Disorders: instructing workers to modify methods of performing tasks to avoid hazardous work practices should be the goal of training programs to prevent CTDs. Manual skills can be easier to communicate by demonstration and are best done in an on-the-job setting. One-on-one instruction can be the most effective.

Back Disorders: instructing workers in the principles of safe lifting is a long recognized effort in industry. These programs can be beneficial; however, there have been no controlled studies showing a drop in back injury rates with one lifting technique versus another. Back care schools are a specific type of training program that attempts to educate the worker in all aspects of back care. It teaches a more comprehensive approach to back care that includes lifting techniques, strength and physical fitness.

The goals of manual material handling training are:

- to make the workers aware of the dangers of careless and unskilled lifting,

- to show them how to avoid unnecessary stress, and

- to teach them individually to be aware of what they can handle safely.

Industrial training programs are easy to implement and have an appeal based on the belief that behavioral change follows awareness and the programs usually cost less than other ergonomic interventions. The programs may not always be cost effective. Over years the costs of on-going training programs may exceed the initial expenses needed to make job process and tool changes. The basic reason for this higher cost is that each new employee must be trained and retrained periodically to reinforce safe practices (11).

Training programs are traditionally focused on teaching specific work practices for safety and hygiene. A recent concept in training programs is to include elements of recognition and problem solving aimed at increasing awareness. It is recognized that this type training is needed at all levels of management, including personnel and compensation specialists, procurement officers, and engineers that are concerned with tool and workplace design and use.

Job Rotation

The purpose of rotating workers from one job to another is to reduce the duration of exposure of one worker to tasks that call for stressful postures, forces and highly repetitive activities.

Some of the problems and disadvantages of the administrative control are:

There is uncertainty about what period of time is an acceptable exposure to the work process; also what amount of recovery time is needed, may be 60 hours or more.

Worker rotation may pose a hazard because the worker may lack experience in the rotated job or have problems adjusting to a new process.

Rotation may violate employment agreements pertaining to job assignments or duties. Also, supervisors may object because of the need to retrain employees and the ultimate loss in experienced workers on a routine basis.

Caution should be exercised when selecting the jobs to which the workers are rotated. The job must be assessed to ensure that the same physical demands of the previous job are not in the new job. If this task is not carefully monitored, the worker may be put at risk with similar hazardous working conditions.

Selecting Workers to Fit Specific Jobs

This task is possibly the least effective and usable of the administrative controls. Attempts to screen potential employees by questionnaires, X rays, and tests of physical fitness have not been proven to be effective and may be viewed as discriminatory. This complex process involves determining the specific demands of the job and an accurate assessment of the worker's capacities. This process is difficult because of the variety of physical job demands in the workplace and the wide range of individual physical capabilities, plus the lack of specific criteria for safely matching workers to jobs.

The civil service employment system that the government uses has many regulations that apply to preemployment practices. Applying the process of worker selection would be difficult.

Engineering Controls

Engineering controls are concerned with redesigning the job to mitigate sources of biomechanical trauma. Unlike administrative controls which are "people solutions," the guiding principle for ergonomic engineering controls is to make the job fit the person, not the person fit the job.

Manual Material Handling (10)

Materials handling can cause overexertion of the musculoskeletal system. To help the worker as a materials handler, material handling alternatives are available.

Key factors to consider are container design and the "couplings" which transmit the container forces through the body to the floor or other working surface.

Container Design: Containers should be as small as possible to allow a load to be lifted from the floor to pass between the worker's legs, thus decreasing spinal disc pressure.

Handles should be placed above the container center of gravity for ease of container control. The handle or hand-hold is the coupling between the container and the worker and should be designed with the worker's hand in mind. Proper container couplings have a large effect on both the maximum force a worker exerts on a container and on the energy expended.

Worker/Floor Surface Coupling: Preventing foot slippage is an important facet of material handling, especially where horizontal inertial forces are transmitted from the container to the body. In general, adjust shoes and working surfaces to give a coefficient of friction of at least 0.4. Unnoticed changes in surface friction are undesirable. Going from a less slippery floor to a more slippery one may produce missteps. These changes can be reduced by ensuring that different surface materials have transition zones between them; are clearly marked; and that good housekeeping procedures are used to reduce spills, worn spots or loose/irregular floors.

Materials Handling Alternatives: Positioning equipment can be used to transfer material from workplace to material handling equipment or vice versa. They include dumpers, positional tables, lifts, jacks, and transfer machines. This equipment provides an alternative to the unaided worker at the workstation itself.

Job aids can facilitate handling tasks. Examples are:

- Hooks: workers should be trained in their use so they will not glance off hard objects.

- Bars: crow bars may slip; the edge should have a good bite.

- Rollers: very effective for moving heavy and bulky objects.

- Jacks: different sizes for different weight loads.

- Platforms: adjusting the height of the surface that the load is lifted from is helpful.

Transfer machines are very useful in moving loads.

- Conveyers: useful when loads are uniform, move continuously, routes do not vary.

- Cranes and hoists: useful when movement is within a fixed area, moves are intermittent, loads vary in size and weight.

- Industrial trucks (fork-lifts, hand stackers, two-wheel hand trucks): useful when material can be put into unit loads and when loads are uniform or mixed in size and weight.

Cumulative Trauma Solutions (11)

Ergonomic principles for changing workplace design are based on the following objectives:

1. Reduction of extreme joint movement.

2. Reduction of excessive force levels.

3. Reduction of highly repetitive and stereotyped movements.

Reduction of Extreme Joint Movement: Work activities should ideally be performed with the joints at their midpoint of range of motion. The wrist should be kept straight and the elbow bent at a right angle; side-to-side movements of the wrist should be avoided.

Examples of methods to reduce deviations of the wrist:

Altering the tool or controls: bend the tool or handle instead of the wrist.

Moving the part: rotate the part in front of the worker so the wrist can be kept straight.

Moving the worker: change the position of the worker in relation to the part.

Reduction of Excessive Force: tasks that require prolonged and excessive muscle contractions to maintain posture should be avoided.

Several approaches to controlling job forces are:

Reducing the force required: keep cutting edges sharp, use weaker springs in triggers, power with motors instead of muscles, use jigs and clamps instead of hands.

Spreading the force: use trigger levers instead of single-finger push buttons and allow the worker to rotate hands.

Getting better mechanical advantage: use strong muscle groups and use tools with longer handles.

Reduction of Highly Repetitive Movements: countermeasures to limit the duration of continuous work or restructuring work methods should be implemented.

Reduction of repetition may be accomplished by:

Task enlargement: restructure jobs so that the worker has a larger and more varied number of tasks to perform; include an increase in job-cycle-time.

Mechanization: use of special tools with ratchet devices or power drivers.

Automation: although costly, can be efficient for high-volume, long-term production processes.

General Guidelines for Design of Workstations:

Design workstations to accommodate a wide majority of people who work on that job. Workstations should be adjustable and be comfortable for 90-95% of the work force. For specific design criteria see AFOEHL Technical Report 90-043, Ergonomics and Radiation Effects of Video Display Terminals and Workstations (1), or Eastman Kodak Co., Ergonomic Design for People at Work (3).

Permit several different working positions to prevent static postures. Armrests and footrests should be available.

Frequent work should be kept within an area that can be easily reached by the hand with the upper arm in a natural position at the side of the body.

Controls, tools, and materials should be located between shoulder and waist height.

In general, the more precise the work, the higher the work surface; the heavier the work, the lower the work surface.

Edges of work surfaces should be well rounded and padded where elbow or forearm may rest.

Well-designed chairs should be available. Both arm and lumbar support should be available for adjustable chair designs.

General Guidelines for Design of Work Methods:

Use jigs and fixtures whenever possible. Adjustable fixtures for holding items eliminates having to hand-hold items or work on pieces lying flat on tables.

Resequence or combine jobs to reduce repetition. Combining small jobs into a longer sequence allows the worker varied movements instead of short repeated cycles.

Allow self-pacing of work when possible and pauses for rest periods. Expect new employees to start at a slower rate.

Automate highly repetitive operations. While this solution may relieve the worker from more strenuous jobs, it often reduces the task to single repeated acts that are done with the hands and wrists.

General Guidelines for Design of Tools and Handles:

Four fundamentals of design are:

1. Avoid high contact forces and static loading.

2. Avoid extreme or awkward joint positions.

3. Avoid repetitive finger action.

4. Avoid tool vibration.

Handles should be provided: the user should not have to grasp motor housings instead of a handle.

Minimum muscular effort should be needed to operate the tool. Power from motors instead of muscles is desirable.

Tool should be bent, not the wrist (Fig. 5). The left side of the illustration shows gripping standard pliers which causes ulnar deviation; and the right side of the illustration shows the wrist in a neutral position. In general, tools with pistol grips should be used where the tool axis is horizontal. A straight grip should be used where the tool axis is vertical.

Keep the tool weight light. The user should be able to hold the tool with one hand.

Handles should be designed so that the hand is able to wrap around for a power grip. Handles that allow this grip are less fatiguing because they require less strength to control the tool. Precision grips, internal (gripping a carving knife) or external (holding a pencil), are used to position a tool but should be avoided for jobs that are intensive and of long duration.

Handle length minimum is 10.2 cm (4 in.) since the average worker's palm is 10.2 cm across. Handles that are too short may dig into the palm, pressing on nerves and reducing blood flow.

Spring-loaded scissors or pliers will allow the worker to use strong hand-closing muscles rather than hand-opening muscles.

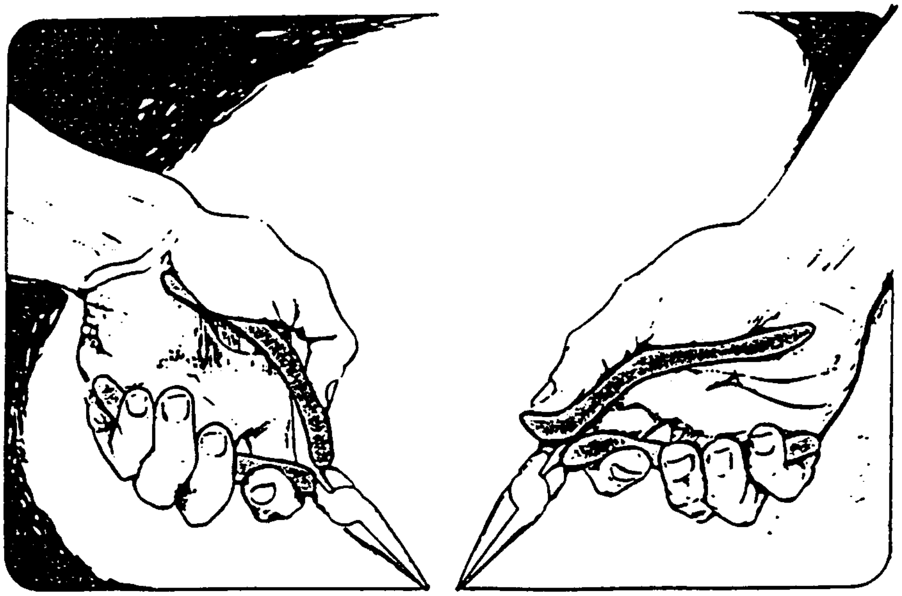


Figure 5. Straight pliers on left cause ulnar deviation; bent pliers on right allow workers to maintain a neutral position.

Reprinted, by permission from Vern Putz-Anderson, "Cumulative Trauma Disorders," 105.

Triggers on power tools should be at least 5.1 cm (2 in.) long so they can be activated by using 2 or 3 fingers.

Handles should be made from nonporous, nonslip, and nonconductive materials. Grasping surfaces should be slip resistant.

Personal Protective Equipment

Back Supports

The use of back supports for the prevention of back injury is common practice in many material handling settings. The debate over their effectiveness continues. There have been very few controlled studies to validate or invalidate their effectiveness. It was once believed that there would be loss of strength in the abdomen with the use of back braces. There are no facts to support this theory. Most empirical observations suggest that the use of back supports combined with an education program about use and general lifting techniques is effective.

There has been some research to demonstrate that an increase in abdominal pressure puts force against the diaphragm and thoracic spine, resulting in a decrease in the load on the lumbar spine (13). Also, the actual wear of the brace is a constant reminder to the worker to use good body mechanics for lifting.

There are numerous models on the market, some with inflatable air bladders, leather materials, those with chest and shoulder straps, and those with moldable inserts. Whichever belt is chosen, the key is proper snug fit where the belt does not move out of position.

Wrist Immobilizers

Wrist immobilizers or splints for the prevention of cumulative trauma disorders of the wrist are also gaining widespread use. The idea behind their use is to minimize the ability of the wrist to flex while performing repeated motion. Most models of splints allow the fingers and thumb to move freely, thus permitting continued use of the hand. Splints have been prescribed by physicians as treatment once the early symptoms of trauma are present and are usually effective if used early. As prevention of CTDs there is little documented evidence to their effectiveness. Primary engineering controls should be implemented so that splints would not have to be worn on a routine basis.

Models available vary in shape, size, and materials. They can be selected depending on the type of task the worker will be doing. Some models give more mobility to the hand than others.

Anti-vibration Gloves/Materials

Eliminating vibration problems should focus first on eliminating the source of vibration. Tool vendors can be contacted to find low vibration tools for the task. If alternatives are not available, then vibration attenuation using personal protective equipment should be considered.

Two general types of protective gear can be used to provide protection from the effects of vibration:

1. Reduces the transmission of vibration energy to the hand: various types of vibration-damping materials are available as either gloves or material to wrap on tool handles. Problems with energy-damping materials are: (a) those providing adequate damping are too thick so dexterity is compromised for efficient tool operation, and (b) few materials have adequate damping characteristics over the vibration frequency that is most harmful.

2. Protects against exposure to cold and trauma: acute episodes of white finger are frequently brought on by exposure of the hands to cold. Some type of hand protection should be used to protect the hands especially in cold weather.

There are several materials available; however, the material selected should be based on the frequency of vibration. There is not one all purpose application (5,9). Table 2 shows commercially available isolation materials and Appendix D gives manufacturers of anti-vibration gloves.

The scope of this report does not include an in-depth discussion of vibration and its attenuation. The National Institute for Occupational Safety and Health has published Criteria for a Recommended Standard: Occupational Exposure to Hand-Arm Vibration, 89-106 (9). This document provides in-depth information on the problems associated with the use of vibrating tools and offers guidelines for reducing the risk of developing vibration induced medical problems.

TABLE 2. COMMERCIALLY AVAILABLE ISOLATION MATERIALS

Material	Manufacturer/Supplier	Material	Manufacturer/Supplier
Chorlastic R10480	CHR Industries, Inc. 407 East Street P.O. Box 1911 New Haven, CT 06509-9988	Sorbothane Mat	Sorbothane Inc. 2144 State Route 59 P.O. Box 178 Kent, OH 44240
EAR C-3002-7#	E-A-R Division Cabot Corporation 7911 Zionsville Road Indianapolis, IN 46268-0898	Spenco Grip	Spenco Medical Corp Waco, TX 76703
		SWS 7810	SWS Silicones Corporation Elastomer Products Adrian, MI 49221
Ensolite Type M 6.5 mm Ensolite Type M 9.5 mm Ensolite Vinyl Nitrile	Expanded Products Department Uniroyal, Inc. Mishawaka, IN 46544	Vibra-sorb Poron	Wolverine Specialty Gloves Division of Shelby Group, Inc. P.O. Box 8735 Grand Rapids, MI 49508
Evalite	Monarch Rubber Company, Inc. 3500-T Pulaski Highway Baltimore, MD 21224		
Neoprene Cellu-Polyethylene EPDM Enso Foam	Creative Foam Corp. 300 North Alloy Drive Fenton, MI 48430	Viscolas Orthex 3.2 mm Viscolas Orthex 4.8 mm Viscolas Orthex 6.4 mm	Chattanooga Corporation Viscolas Division 101 Memorial Drive P.O. Box 4287 Chattanooga, TN 37405
Poron 4716-16 Poron 4716-01 Poron 4701-09	Rogers Corporation Poron and Composites Division Box 156 East Woodstock, CT 06244	Minicel (incorrectly named Sensifoam 3693) Volara EE	Voltek Division of Sekisui 73 Shepard Street Lawrence, MA 01843

REFERENCES

1. Bright, P. D.; N. D. Montgomery; and P. L. French. Ergonomics and Radiation Effects from Video Display Terminals and Workstations. AFOEHL Report 90-043, Apr 1990.

2. Burnette, J. T.; and M. A. Ayoub. Cumulative Trauma Disorders: Part I. pp. 196-209, The Problem, Pain Management, Jul/Aug 1989.

3. Eastman Kodak Company. Ergonomic Design for People at Work, Vol. 1, Van Nostrand Reinhold, 1983.

4. Gross, C. M.; and A. Fuchs. Reduce Musculoskeletal Injuries with Corporate Ergonomics Program, pp. 28-33, Occupational Health and Safety, Jan 1990.

5. Hampel, G. A.; and W. J. Hanson. Hand Vibration Isolation: A Study of Various Materials, Applied Occupational and Environmental Hygiene, 5(12):859-869 (1990).

6. Joyce, M. Ergonomics Will Take Center Stage During '90s and into New Century, pp. 31-37, Occupational Health and Safety, Jan 1991.

7. Katz, J. N.; M. G. Larson; A. H. Lassel; and M. H. Liang. Validation of a Surveillance Case Definition of Carpal Tunnel Syndrome, American Journal of Public Health, 81(2):189-193 (1991).

8. Keyserling, W. M.; T. J. Armstrong; and L. Punnett. Ergonomic Job Analysis: A Structured Approach for Identifying Risk Factors Associated With Overexertion Injuries and Disorders, Applied Occupational and Environmental Hygiene, 5(5):353-363 (1991).

9. NIOSH, Criteria for a Recommended Standard: Occupational Exposure to Hand-Arm Vibration, Sept 1989 (89-106).

10. NIOSH, Technical Report, Work Practices Guide for Manual Lifting, Mar 1981 (81-122).

11. Putz-Anderson, V. Cumulative Trauma Disorders: A Manual for Musculoskeletal Diseases of the Upper Limbs, Taylor and Francis, 1988.

12. Snook, S. H. Comparison of Different Approaches for the Prevention of Low Back Pain, Ergonomic Interventions, Chapter 5, 1978.

13. Walsh, N. E.; and R. Schwartz. The Influence of Prophylactic Orthoses on Abdominal Strength and Low Back Injury in the Workplace, American Journal of Physical Medicine and Rehabilitation, 69(5) pp. 245-250 (1990).

BIBLIOGRAPHY

1. Armstrong, T. J. An Ergonomic Guide to Carpal Tunnel Syndrome, Ergonomics Guide, American Industrial Hygiene Assoc., 1983.

2. Armstrong, T. J.; L. J. Fine; R. G. Radwin; and B. S. Silverstein. Ergonomics and the Effects of Vibration in Hand Intensive Work, Scandinavian Journal of Work and Environmental Health, 13:286-289 (1987).

3. Ayoub, M. A. Ergonomic Deficiencies: I. Pain at Work, Journal of Occupational Medicine, 32(1):52-57 (1990).

4. Barrer, S. Gaining the Upper Hand on Carpal Tunnel Syndrome, pp. 38-43, Occupational Health and Safety, Jan 1991.

5. Burnette, J. T.; and M. A. Ayoub. Cumulative Trauma Disorders: Part II. pp. 256-264, Assessment of Risk, Pain Management, Sept/Oct 1989.

6. Fine, L. J.; B. S. Silverstein; T. J. Armstrong; C. A. Anderson; and D. S. Sugano. Detection of Cumulative Trauma Disorders of Upper Extremities in the Workplace, Journal of Occupational Medicine, 28(8):674-678 (1986).

7. Goel, V. K.; and K. Rim. Role of Gloves in Reducing Vibration: An Analysis for Pneumatic Clipping Hammer, American Industrial Hygiene Association Journal, 48(1):9-14 (1987).

8. Goldoftas, B. Hands that Hurt, Technology Review, Jan 91.

9. Grandjean, E. Fitting the Task to the Man: An Ergonomic Approach, Taylor and Francis, 1988.

10. Habes, D. J.; and V. Putz-Anderson. The NIOSH Program for Evaluating Biomechnical Hazards in the Workplace, Journal of Safety Research, 16(2):49-60 (Summer 85).

11. Handler, N. Regional Musculoskeletal Diseases of the Low Back: Cumulative Trauma versus Single Incident, Clinical Orthopaedics and Related Research, 221:33-41 (1987).

12. Jackson, L. C. Ergonomics and the Occupational Health Nurse: Instituting a Workplace Program, AAOHN Journal, 39(3):119-127 (1991).

13. Jetzer, T. Use of Vibration Testing in the Early Evaluation of Workers with Carpal Tunnel Syndrome, Journal of Occupational Medicine, 33(2):117-120 (1991).

14. Morbidity and Mortality Weekly Report, Jul 21, 1989, Vol. 38 No. 28, Current Trends: Occupational Disease Surveillance: Carpal Tunnel Syndrome.

15. Occupational Safety and Health Reporter, Special Report: Diverse Work-force Posing New Challenges in Designing Ergonomic Workplaces, Group Told, Nov 1990.

16. OSHA Guidelines for Establishing Ergonomics Programs in Meatpacking Plants, 1990.

17. Tichauer, E. R.; and H. Gage. Ergonomic Principles Basic to Hand Tool Design, American Industrial Hygiene Association Journal, 38(11):622-634 (1977).

18. Van Bergeyk, E. Ergonomic Interventions, Chapter 12, Selection of Power Tools and Mechanical Assists for Control of Occupational Hand and Wrist Injuries.

APPENDIX A

SAMPLE QUESTIONNAIRES, CHECKLISTS, AND BODY PART DISCOMFORT FORMS

ERGONOMIC SCREENING QUESTIONNAIRE

INSTALLATION: ______________ **ORGANIZATION:** ____________________

TODAY'S DATE: ____________ **WHEN DID YOU BEGIN WORKING HERE? MO**____ **YR**____

SEX: M F **AGE:** _______ **HEIGHT:** ___ft. ___in. **WEIGHT:** _____lbs.

JOB TITLE: ____________________________ **HANDEDNESS:** right left

HOURS WORKED: per day _________ per week __________

MEDICAL HISTORY

1. In the last 5 years have you been diagnosed with or treated for any of the following: Circle yes or no.

a.	impaired or poor circulation	yes	no
b.	tendonitis or tenosynovitis	yes	no
c.	synovitis	yes	no
d.	bursitis	yes	no
e.	epicondylitis	yes	no
f.	carpel tunnel syndrome	yes	no
g.	injury to the wrist (break, sprain, etc.)	yes	no
h.	injury to the arm (break, sprain, etc.)	yes	no
i.	injury to the shoulder (break, sprain, etc.)	yes	no
j.	injury to the neck (sprain etc.)	yes	no
k.	injury to the back (break, sprian, etc.)	yes	no

2. Have you ever had surgery on any of the following body areas? Circle yes or no.

a.	the wrist	yes	no
b.	the arm	yes	no
c.	the shoulder	yes	no
d.	the neck	yes	no
e.	the back	yes	no

3. Are you currently: Circle yes or no.

a.	pregnant	yes	no
b.	using birth control pills	yes	no
c.	taking synthetic hormones	yes	no
d.	in or past menopause	yes	no

4. What do you do on a regular basis when you are not working at your regular job. Please check all the following that apply and add any activities not included on the list.

LEISURE:

racquetball/tennis	_____	swimming	_____
bowling	_____	aerobics	_____
skiing	_____	workouts w/wts.	_____
golf	_____	fishing	_____
horseback riding	_____	other (specify)	_____
		_____________________	

HOME:

housework	_____
yardwork	_____
maintenance/remodeling	_____
cooking	_____
needlework/knitting	_____
other (specify)	_________________________

5. Do you have a second job? Circle one: yes no

6. If yes: Job Title: ______________________________________

Brief Description of Duties: ____

____

Hours Worked: per week _________ per day __________

Please complete the **BODY PART DISCOMFORT FORM** attached. Use the discomfort rating scale located at the bottom of the page to rate any discomfort you are having in the various body parts identified.

ALL INFORMATION CONTAINED IN THIS QUESTIONNAIRE IS CONFIDENTIAL.

BASELINE ERGONOMICS WORKPLACE SURVEY FOR REPETITIVE TRAUMA DISORDERS

WORK AREA ______________________ SUPERVISOR ______________________

BUILDING NUMBER ______________ TELEPHONE NUMBER ______________________

AFSC ________________________ OSC ______________________________

GENERAL JOB DESCRIPTION ____

____

____

____

	YES	NO
WORKPLACE DESIGN		
1. Is the workstation adjustable to different body sizes?		
2. Are all materials and tools accessible and in front of the worker?		
3. Is there sufficient work space for the whole body to turn, stoop or bend without constraint?		
4. Are stable and adjustable chairs with lumbar support provided?		
5. Are elbow, wrist, arm and foot rest provided where needed?		
6. Are controls and displays easy to read, reach and operate?		
JOB DEMANDS		
1. Are workers allowed to alternate sitting and standing positions as needed?		
2. Does the job avoid exerting more than 10 lbs of force?		
3. Can the job be done without flexion or extension of the wrist?		
4. Can the job be done without a "clothes wringing" motion of the hands?		
5. Is the task cycle time longer than 30 seconds?		
6. Are tasks involving the placement of tensed muscles in fixed or awkward positions for long periods of time avoided?		

JOB DEMANDS (Cont.)

YES NO

7. Do arm movements pivot about the elbow rather than the shoulder to avoid stress on shoulder, neck and upper back?

8. Does the task avoid exerting forces in awkward positions: to the side, while twisting the torso, or extended reaches?

MATERIALS HANDLING

1. Does the task avoid repetitive lifting or lowering between floor and waist height, or lifting or lowering above shoulder height?

2. Is lifting, lowering or carrying more than 22 lbs avoided?

3. Is lifting or lowering items with one hand avoided?

4. Can all bulky objects lifted or carried be held close to the body?

5. Does the task avoid handling difficult-to-grasp items?

6. Does the task avoid pushing or pulling materials (i.e., boxes) that require large break-away forces to get started?

EQUIPMENT/TOOL DESIGN

1. Is the weight of the tool below 9 lbs?

2. Is the tool suspended?

3. If gloves are used, are they:
   a) well fitting to maximize grip strength?

   b) made of material that allows maximum coefficient of friction when gripping tools?

4. Is the hand tool designed to:
   a) eliminate sharp edges over ridges which might impair circulation/exert pressure on the nerves?

   b) avoid excessive grip force to maintain the tool in a stable position?

   c) form a natural extension of the lower arm?

   d) be used without bending or rotating the wrists?

   e) be operated with a full power grip, rather than a precision grip?

EQUIPMENT/TOOL DESIGN (Cont.)

	YES	NO
f) be held with the thumb and finger slightly overlapped in a closed grip?		
5. Are hand tools equipped with handles shaped to contact as much of the hand and finger as possible?		
6. Are hand tools equipped with handles made of compressible materials rather than hard plastic or metal?		
7. Are repetitive trigger-finger actions avoided?		
8. Are hands protected from heat, cold, and vibration?		

SUMMARY:

Potential High-Risk Activities:

Recommendations:

Need for Follow-up:

Note: This checklist has been adapted from Ridyard, David T. et al., "Ergonomics Awareness Training for Workplace Design Engineers." Applied Occupational Env. Hyg., 5(11), Nov 90, and Lifshitz, Y. and Armstrong, T., "A Design Checklist for Control Prediction of Cumulative Trauma Disorders in Hand Intensive Manual Jobs." Proceedings of the 30th Annual Meeting of Human Factors Society, pp 837-41, 1986. Additional information on task cycles obtained from Putz-Anderson, V. Cumulative Trauma Disorders, Taylor and Francis, London, 1988.

CHAIR FEATURE CHECKLIST

Instructions to Subject:

Below is a list of chair features which contribute to comfort. On the right hand side of the page, opposite each feature, are three brief phrases descriptive of the feature. Mark on the line with an **X** at a point which describes the opinion you have of that feature.

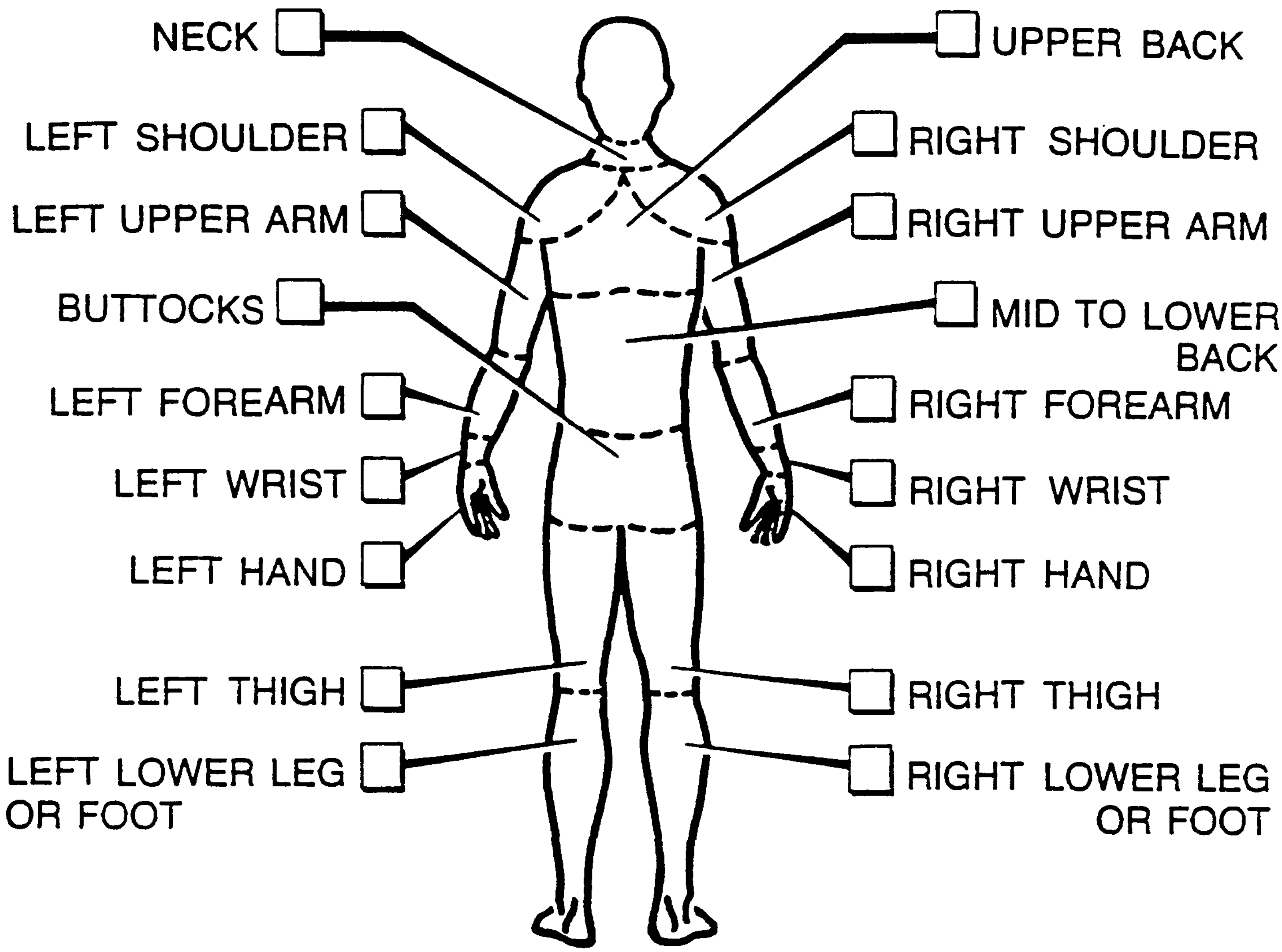
SEAT:

Feature			
Seat height above the floor.	low	correct	high
Seat length.	short	correct	long
Seat width	narrow	correct	wide
Slope of seat.	slopes backward	correct	slopes forward
Seat shape.	poor fit	adequate	fits well

BACK SUPPORT:

Feature			
Position of backrest.	low	correct	high
Molded chair back.	poor fit	adequate	fits well
Curvature of back support.	flat	correct	curved
Clearance for feet and calves under chair.	obstructed	adequate	unobstructed

Courtesy, National Institute for Occupational Safety and Health, Cincinnati, OH.



DISCOMFORT RATING SCALE

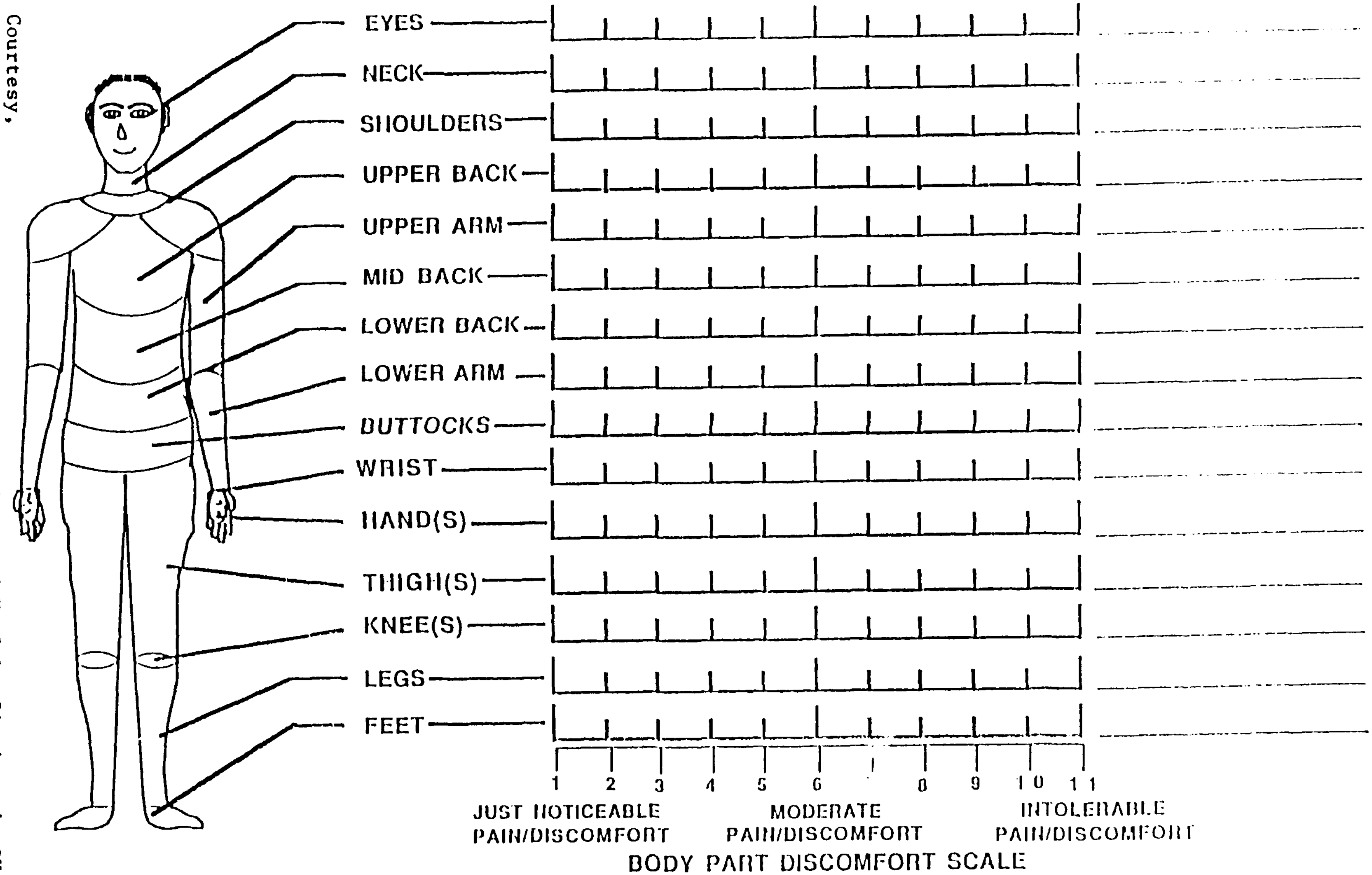
0	Nothing at all
0.5	Very, very weak
1	Very weak
2	Weak
3	Moderate
4	Somewhat strong
5	Strong
6	
7	Very strong
8	
9	
10	Very, very strong Maximal

Courtesy, National Institute for Occupational Safety and Health, Cincinnati, OH.

Name: ____________ **Workstation/Job:** ____________ **Dept.:** ______ **Date:**

Age:____ **Weight**______ **Height**_____ **Gender:** M__ F__ **Shift:** 1st__ 2nd__ 3rd__ **Vision:** 20/___ **Eye Glasses** **Contacts**

WHY?



How do you feel during or after you have completed your required work activities?
Place an X or a √ along the scale that best describes how you feel, for each body part on the figure above.
If you have no pain or discomfort for any one of the body parts on the figure, leave that body part blank.

Courtesy,
National Institute for Occupational Safety and Health, Cincinnati, OH.

ERGONOMIC CHECKLIST FOR VDTs/WORKPLACES

A. DISPLAY

( ) Character color (yellow, orange, green, white)
( ) Character height, 3 mm. or greater
( ) Visual angle (character height versus viewing distance) of 20 minutes of arc
( ) Dot matrix: 5x7, 7x9 (better), 9x11 (best), or more
( ) Character width versus height (.70 to .80)
( ) Stroke width versus character height (.12 to .17)
( ) Character spacing versus character height (.20 to .50)
( ) Row spacing versus character height (1.00 to 1.50)
( ) Adjustable screen orientation (horizontal and vertical)
( ) Screen angle versus seated eye height and visual posture (10^{o})
( ) Compatibility of VDT format and source document formats
( ) Filters--adverse effect on character luminance?
( ) Character luminance: greater than 45 cd/m^2 (minimum); 80 to 160 cd/m^2 (preferred)
( ) Adjustable character luminance?
( ) Character-background contrast: minimum of 3 to 1; better, 5 to 1; optimal, 8 or 10 to 1
( ) Contrast--screen versus documents--of about 3 to 1
( ) Stability of characters/flicker?

B. KEYBOARD

( ) Detachable? Friction resistance to slippage
( ) Height adjustable to operator comfort?
( ) Keyboard profile, angle (5^{o} to 15^{o})
( ) Matte finish? Reflectance?
( ) Palm rest/space?
( ) Key pressure, travel, size (0.6" square), spacing (0.7")
( ) Key shape (concave), legends resistant to abrasion
( ) Feedback?
( ) Numerics--telephone layout
( ) Color coding; alphanumerics neutral color?

C. WORKPLACE

( ) Ample desk space for operator
( ) Desk height -- 27" or adjustable (25"-30")
( ) Leg and thigh clearance; obstructions
( ) Matte finish
( ) Footrest -- needed, adjustable?
( ) Chair stability, e.g. 5-point base; casters
( ) Seat height adjustable easily (15" to 20" from floor)
( ) Seat depth (17" or less) and width (16" minimum) suit operator comfort
( ) Seat padding; front edge rounded
( ) Backrest and angle (110^{o}-120^{o}) adjustable
( ) Matte paper surfaces
( ) Upper arms vertical; elbows in close to body
( ) Keyboard task at or below elbow level
( ) Wrist straight with forearm

( ) Head and neck posture
( ) Eye-screen distance (15" to 32")
( ) Armrests needed? Adjustable?
( ) Lumbar support 4" to 8" above seat pan

D. ENVIRONMENT

( ) Illuminance between 300 and 400 lux; adjustable. Prefer 200 lux for screen
( ) Direct glare? Windows?
( ) Indirect lighting
( ) Louvers; screening
( ) VDT oriented parallel to luminaires and windows
( ) Reflectances: ceilings (0.7); walls (0.5 to 0.7); floor (0.3).
( ) Air conditioning
( ) Noise level below 65 dB(A) or, better, below 55 dB(A)
( ) Contrast ratio (10:1)--screen to far surround

E. OTHER

( ) Visual examination (annual)
( ) Privacy for operator
( ) Document holder, $70^{\circ} \pm 10^{\circ}$ angle
( ) Document luminance -- 500 lux, if supplemental lighting; otherwise use 300-400 lux for screen and document
( ) Office cleaning and equipment maintenance requires luminance of 500 lux to 1000 lux (best)

Reprinted, by permission from Richard G. Pearson, Department of Industrial Engineering, North Carolina State University

APPENDIX B

NIOSH Work Practices Guide for Manual Lifting

Chapter 8

CHAPTER 8

RECOMMENDATIONS

This chapter outlines load limit recommendations for lifting tasks. Sections on how to identify a hazardous lifting job, how to interpret the guidelines and how to apply them to actual lifting situations are provided. In addition, brief summaries of Chapter 6, Administrative Controls and Chapter 7, Engineering Controls, are included.

It is intended that this chapter will provide the Industrial or Safety Engineer with an easy means to quickly scan the Guide, pick out important points and apply them to the appropriate situation. References to earlier chapters are made if a more thorough and detailed discussion of a topic is desired.

DEFINITION OF A LIFTING TASK

For the purpose of this Guide, a lifting task is considered to be the act of manually grasping and raising an object of definable size without mechanical aids (i.e., hoists, conveyors, block and tackle, etc.). The time duration of such an act is normally less than two seconds, and thus little sustained exertion is required (as opposed to holding or carrying activities). The lifting limits presented in this chapter do not apply to all kinds of lifts. They are intended to apply only for:

a. smooth lifting
b. two-handed, symmetric lifting in the saggital plane (directly in front of the body; no twisting during lift)
c. moderate width, e.g., 75 cm (30 in) or less
d. unrestricted lifting posture
e. good couplings (handles, shoes, floor surface)
f. favorable ambient environments.

It is assumed that other manual handling activities such as holding, carrying, pushing, pulling, etc., are minimal. When not engaged in lifting activities, the individual is assumed at rest. The assumed work force is physically fit and accustomed to physical labor.

<u>The Guide does not include "safety factors" commonly used by engineers to assure that unpredicted conditions are accommodated.</u>

LIFTING TASK VARIABLES

The primary task variables identified earlier in this Guide on the basis of epidemiology (Chapter 2), biomechanics (Chapter 3), physiology (Chapter 4) and psychophysics (Chapter 5) of lifting include:

1. Object weight (L) - measured in kilograms (pounds)

2. Horizontal location (H) - of the hands at origin of lift measured forward of the body centerline or midpoint between ankles (in centimeters or inches)

3. Vertical location (V) - of the hands at origin of lift measured from floor level in centimeters (inches)

4. Vertical travel distance (D) - from origin to destination of lift in centimeters (inches)

5. Frequency of lifting (F) - average number of lifts per minute

6. Duration or period - assumed to be occasional (less than one hour) or continuous (8 hours)

The latter two variables (lift frequency and period) are the most difficult to define and consequently measure and provide guidance. For the purpose of this Guide jobs will be grossly classified in three categories:

1. Infrequent - either occasional or continuous lifting less than once per 3 minutes

2. Occasional high frequency - lifting one or more times per 3 minutes for a period up to 1 hour

3. Continuous high frequency - lifting one or more times per 3 minutes continuously for 8 hours.

Evidence presented in earlier chapters shows that for <u>infrequent lifting</u> a person's musculoskeletal strength (Chapter 5) and potential high stress to the back (Chapter 3) are the primary limitations to ability. As such, biomechanical variables are predominant in determining hazard. <u>Occasional high frequency lifting</u> results in psychophysical stress (Chapter 5) and possible muscle fatigue as the primary limitations. For <u>continuous, high frequency lifting</u> the primary limitations are based on cardiovascular capacity and metabolic endurance (Chapter 4).

Table 8.1 summarizes which task variables are emphasized by the four approaches examined in Chapters 2-5. A careful review of these approaches shows two important points. First, all of the task variables are highly interactive. In other words, the

Table 8.1: Emphasis on task variables by alternative approaches.

	Epidemiology (Ch. 2)	Biomechanics (Ch. 3)	Physiology (Ch. 4)	Psychophysics (Ch. 5)
Object Weight (L)	X	X	X	X
Horizontal Location (H)	X	X	X	X
Vertical Location (V)	X	X	X	X
Travel Distance (D)			X	X
Frequency of Lift (F)	X		X	X
Duration or Period (P)			X	

importance of object weight (for example) is highly dependent on where the weight is located (horizontally and vertically), how far it must be moved, and how frequently. Thus, none of these variables should be evaluated independently.

Secondly, the four approaches taken separately may lead to different conclusions. For example, metabolic criteria (Chapter 4) can lead one to believe lifting heavy loads infrequently is preferred to frequent lifting of lesser loads (due to the cost of moving the body). From a biomechanical or strength point of view, (Chapters 3, 5) object weight should be minimized regardless of frequency.

Another example has to do with object location. A person is generally strongest when lifting with the legs and back. Were strength the only criterion, (Chapter 5) one would favor leaving objects on the floor rather than on shelves. Of course, biomechanical low back compression (Chapter 3) and cardiovascular (Chapter 4) criteria would deem this least desirable.

CRITERIA FOR GUIDELINE

It is concluded, regardless of the approach taken to evaluate the physical stresses of lifting, that a large individual variability in risk of injury and lifting performance capability exists in the population today. This realization requires that the resulting controls be of both an engineering and administrative nature. In other words, there are some lifting situations which are so hazardous that only a few people could be expected to be capable of safely performing them. These conditions need to be modified to reduce stresses through job redesign. On the other hand, some lifting conditions may be safely tolerated by some people, but others, particularly weaker individuals, must be protected by an aggressive selection and training program. To specifically define these conditions two limits are provided based on epidemiological, biomechanical, physiological, and psychophysical criteria.

1. Maximum Permissible Limit (MPL)

   This limit is defined to best meet the four criteria:

   a. Musculoskeletal injury rates and severity rates have been shown to increase significantly in populations when work is performed above the MPL.

   b. Biomechanical compression forces on the L_5/S_1 disc are not tolerable over 650 kg (1430 lb) in most worker This would result from conditions above the MPL.

   c. Metabolic rates would exceed 5.0 Kcal/minute for most individuals working above the MPL.

   d. Only about 25% of men and less than 1% of women workers have the muscle strengths to be capable of performing work above the MPL.

2. Action Limit (AL)

   The large variability in capacities between individuals in the population indicates the need for administrative controls when conditions exceed this limit based on:

   a. Musculoskeletal injury incidence and severity rates increase moderately in populations exposed to lifting conditions described by the AL.

b. A 350 kg (770 lb) compression force on the L_5/S_1 disc can be tolerated by most young, healthy workers. Such forces would be created by conditions described by the AL.

c. Metabolic rates would exceed 3.5 for most individuals working above the AL.

d. Over 75% of women and over 99% of men could lift loads described by the AL.

Thus, properly analyzed lifting tasks may be of 3 types:

1. those above the MPL should be viewed as unacceptable and require engineering controls

2. those between the AL and MPL are unacceptable without administrative or engineering controls

3. those below the AL are believed to represent nominal risk to most industrial workforces.

To illustrate this point, Figure 8.1 shows the three regions and boundaries defined for infrequent lifting ($F < .2$) from the floor ($V = 15$ cm [6 in]) to knuckle height ($D = 60$ cm [24 in]). Depending on the size of the object, in terms of horizontal hand location, the maximum weight which can be lifted can be determined.

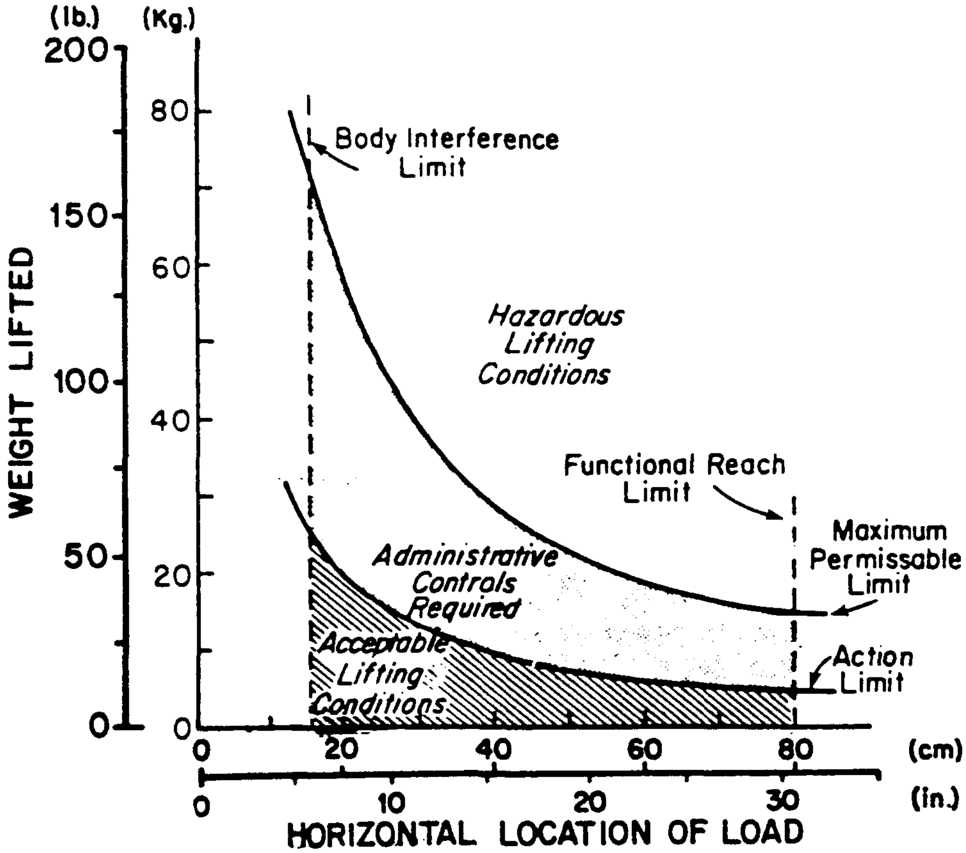


Figure 8.1: Maximum Weight versus Horizontal Location for Infrequent Lifts from Floor to Knuckle Height

GUIDELINE LIMITS

With the large number of task variables (5 in this case) which modify risk during lifting it is virtually impossible to provide a simple yet accurate procedure for evaluating all possible jobs. This problem is further complicated by the need to satisfy four separate criteria (epidemiological, biomechanical, physiological, and psychophysical). The following guideline is the simplest form known which best satisfies the four criteria.

In algebraic form:

$$AL\ (Kg) = 40(15/H)(1-.004|V-75|)(.7+7.5/D)(1-F/F_{max}) \text{-metric units}$$

or

$$AL\ (lb) = 90(6/H)(1-.01|V-30|)(.7+3/D)(1-F/F_{max}) \text{-U.S. Customary units}$$

$$MPL = 3\ (AL)$$

where H = horizontal location (centimeters or inches) forward of midpoint between ankles at origin of lift

V = vertical location (centimeters or inches) at origin of lift

D = vertical travel distance (centimeters or inches) between origin and destination of lift

F = average frequency of lift (lifts/minute)

F_{max} = maximum frequency which can be sustained (see Table 8.2)

For purposes of this Guide, these variables are assumed to have the following limits.

1. H is between 15 cm (6 in) and 80 cm (32 in). Objects cannot, in general, be closer than 15 cm (6 in) without interference with the body. Objects further than 80 cm (32 in) cannot be reached by many people.

2. V is assumed between 0 cm and 175 cm (70 in) representing the range of vertical reach for most people.

3. D is assumed between 25 cm (10 in) and (200-V) cm [(80-V) in]. For travel less than 25 cm, set D = 25.

4. F is assumed between .2 (one lift every 5 minutes) and F_{max} (see Table 8.2). For lifting less frequently than once per 5 minutes, set F = 0.

Table 8.2: F_{max} Table.

		AVERAGE VERTICAL LOCATION (cm)(in)	
		$V > 75$ (30) Standing	$V \leq 75$ (30) Stooped
PERIOD	1 hour	18	15
	8 hours	15	12

The above equations for the action limit (AL) and maximum permissable limit (MPL) represent a multiplicative factor weighting for each task variable. The first factor

$$\text{H Factor} = (15/H)$$

represents the importance of the horizontal location (H). If H = 15 cm this factor is 1 and no adjustment for horizontal location is necessary. If H = 75 cm, this factor is 15/75 = .20 meaning the AL is reduced from 40 to 40(.20) = 8 kg.

The factor for vertical location involves the absolute deviation of V from 75 cm (approximate knuckle height). For V = 75, the V factor is

$$\text{V Factor} = (1-.004|V-75|)$$

$$= (1-.004(0)) = 1$$

For V = 15,

$$\text{V Factor} = (1-.004|15-75|)$$

$$= 1-.004(60) = .76$$

Likewise for V = 135,

$$\text{V Factor} = (1-.004|135-75|)$$

$$= 1-.004(60) = .76$$

Likewise, the D factor ranges from 1 to .74 as D varies from 0 to 200 cm.

$$D\ Factor - (.7+7.5/D)$$

For D = 0 set D = 25 (the minimum allowed value), then

$$D\ Factor = (.7+7.5/25) = 1.0$$

For D = 200,

$$D\ Factor = (.7+7.5/200) = .74$$

The F factor is a bit more complicated. If the lifting originates below 75 centimeters (on the average $V \leq 75$) and is performed continuously throughout the day, $F_{max} = 12$ (as given in Table 8.2). If the observed frequency is 6 lifts per minute (F = 6) then,

$$F\ Factor = (1-F/F_{max})$$

$$= 1-6/12 = .5$$

The effective weight which can be lifted is thus halved due to frequency of lifting required.

Combining factors is illustrated for continuous lifting below knuckle height with average H = 20 cm, V = 40 cm, an average distance of D = 100 cm, at a rate of 6 lifts per minute; then

$$AL = 40\ (15/20)(1-.004|40-75|)(.7+7.5/100)(1-6/12)$$

$$= 40\ (.75)(.86)(.78)(.5) = 10\ kg.$$

$$MPL = 30\ kg.$$

The mechanics of this example would be exactly the same using the U.S. Customary form of the equation and the task variable limits given on page 120. The weight handled on the job could be compared directly with these values. Suppose the load was 35 kg (above the MPL). In this case, one "engineering control" might be to reduce the frequency of lifting from 6 per minute to 1 per minute (admittedly a drastic change). This would increase the frequency factor from .5 to .92 and consequently the

$$AL = 18.4, \text{ and}$$

$$MPL = 55.2$$

Viewing the relative weights of each factor (.75)(.86)(.75)(.50) in this case allows a quick evaluation of the relative weights associated with changes in any factor. Frequency of lifting is the biggest discounting factor (.5, in this case and should receive first consideration.

Reducing frequency to 1 lift per minute would lower the stressfulness of the job to within the "administrative controls" region. In this case, 35 kg is between AL = 18.4 and MPL = 55.2. This should not preclude further "engineering controls". It is important to realize that the job still cannot be safely performed by most women or the majority of men. Further reductions in the frequency (factor = .92) would be ineffective since this factor can only increase to 1.0. The load probably cannot be brought appreciably closer to the body (H = 15 versus H = 20 cm).

The best engineering solution at this point would be to change the load weight. Halving the weight (from 35 kg to 18 kg) would be one solution to achieving a task within the capabilities of most people (18 kg is less than AL = 18.4 kg). An equally acceptable solution would be to increase the load to 100 or more kg and provide mechanical lifting aids thus precluding manual handling and relieving the person of lifting altogether.

JOB PHYSICAL STRESS EVALUATION

The purpose of the job physical demands evaluation is to identify, quantify and document the physical stresses associated with a given job. This section outlines how such an evaluation should be performed so that the guidance of the previous section may be applied.

Selection of Analysts

All job analyses should be performed by an individual who has experience in work measurement and who is thoroughly familiar with the plant and the jobs done in it. The analyst should know the prescribed methods of performing these jobs and should be aware of all tasks (including any irregularly occurring tasks) associated with the job.

Selection of Employees

Only experienced employees who routinely perform their work according to job descriptions and who work at a normal pace should be selected for measurement during the job evaluation. This will assure that the job description accurately describes the work performed.

Selection of Jobs

Jobs should be rank ordered by incidence and severity rates of musculoskeletal disorders. Jobs with the highest rank should be studied first. The primary source used to formulate this sort of job ranking should come from medical information (if available) such as:

- medical reports
- first aid reports
- OSHA 101 forms
- worker's compensation payments

Things to look for on these reports include:

1. musculoskeletal injuries, particularly back injuries

    - overexertion
    - strains/sprains
    - contact injuries such as:
        - lacerations
        - bruises
        - abrasions
        - fractures

2. what job the injury occurred on so that a total for each job can be compiled

3. how much lost time was associated with each injury. In the absence of medical records, stressful jobs can be identified by information obtained from line supervisors or foremen for a particular job, such as:

    - is there a high turnover rate?
    - is there frequent absenteeism?
    - are there frequent sprain/strain complaints?

Analysis Procedures

All data collected should be organized on a "Physical Stress Job Analysis Sheet" (see Figure 8.2). The exact form is, of course, optional but it should include background and identification information for each job such as date, plant name, department, analyst's name and job title as well as the task descriptors to be measured. These are:

1. Weight of the object lifted - determined by direct weighing. If this varies from time to time, note the average and maximum weights.

2. The position of the load with respect to the body - this must be measured at both the starting and ending points of a lift in terms of horizontal and vertical location. The horizontal location from the body (H) is measured from the midpoint of the line joining the ankles to the midpoint at which the hands grasp the object while in the lifting position. The vertical component is

PHYSICAL STRESS JOB ANALYSIS SHEET

DEPARTMENT ______________________ **DATE** ____________

JOB TITLE ______________ **ANALYST'S NAME** ____________

TASK DESCRIPTION	OBJECT WEIGHT		HAND LOCATION				TASK FREQ	AL	MPL	REMARKS
			Origin		Destination					
	Ave	Max	H cm	V cm	H cm	V cm				

Figure 8.2: Example Coding Form.

determined by measuring the distance from the floor to the point at which the hands grasp the object. The coordinate system is illustrated in Figure 8.3.

These measures are repeated for the ending point of the lift (in the lifting position) and all four values are recorded on the job analysis sheet.

If these four values vary from task to task (e.g., stacking cartons on top of each other), the job must be separated into elements and each element evaluated. Examples later will suggest ways to handle such situations.

To be precise, the H value should be measured as described in item 2. However, a convenient rule of thumb is H = (W/2+15) cm or (W/2+6) in, where W = the distance of the load away from the body measured in the horizontal axis (fig. 8.3).

3. Frequency of lift - this should be recorded on the job analysis sheet in average lifts/min. for high frequency jobs. A separate frequency should be entered for each distinguishable job task.

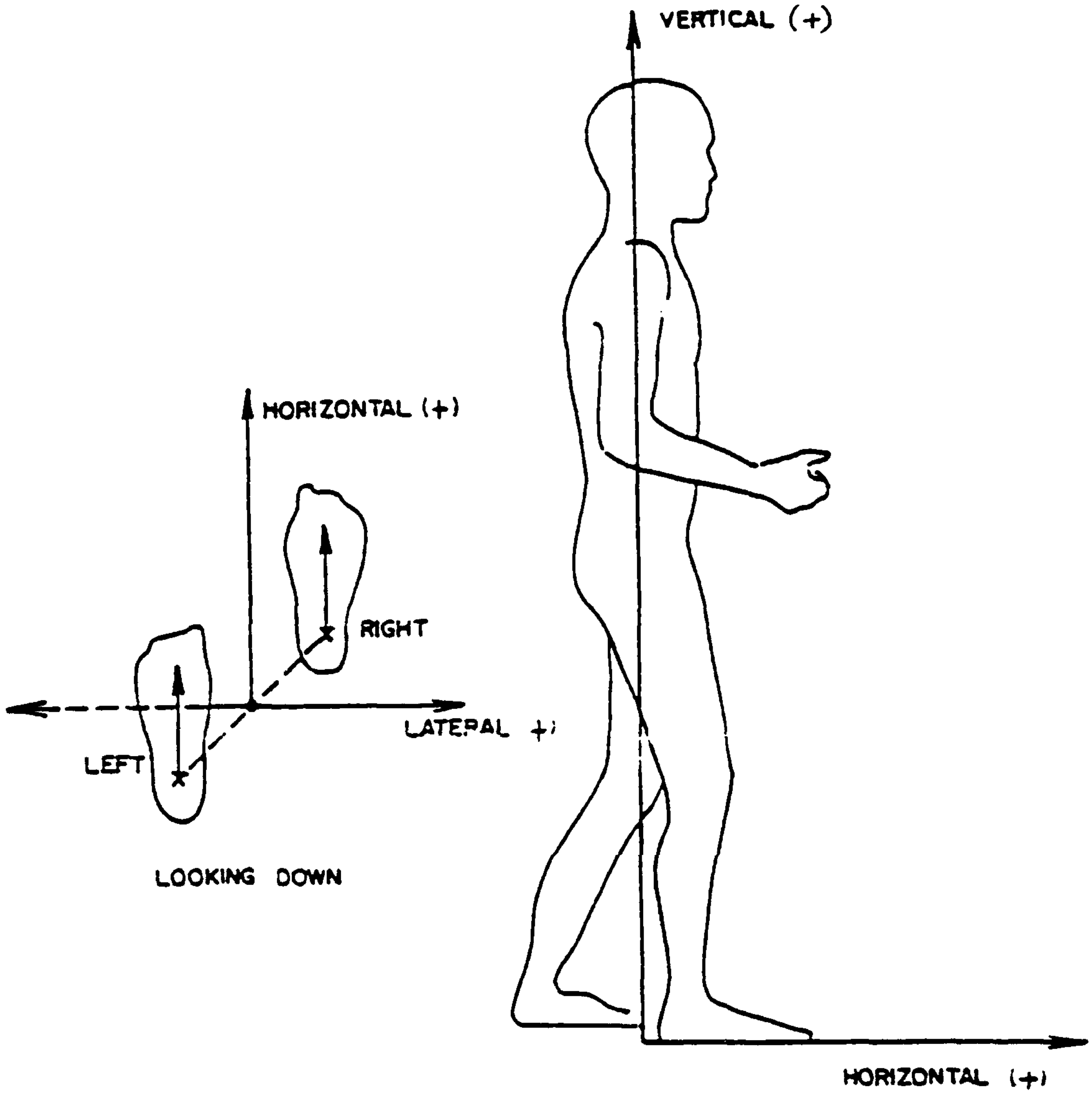


Figure 8.3 Graphic Representation of Vertical, Lateral and Horizontal Axes.

4. Period (or Duration) - the total time engaged in lifting should be noted. This need only be defined as less than one hour or more than one hour for the purposes of this Guide.

Figures 8.4 through 8.7 illustrate the factor weights for each of the above task variables. These nomograms allow the analyst to quickly determine the correct factor adjustments to be applied for each variable in order to complete the latter columns of the job

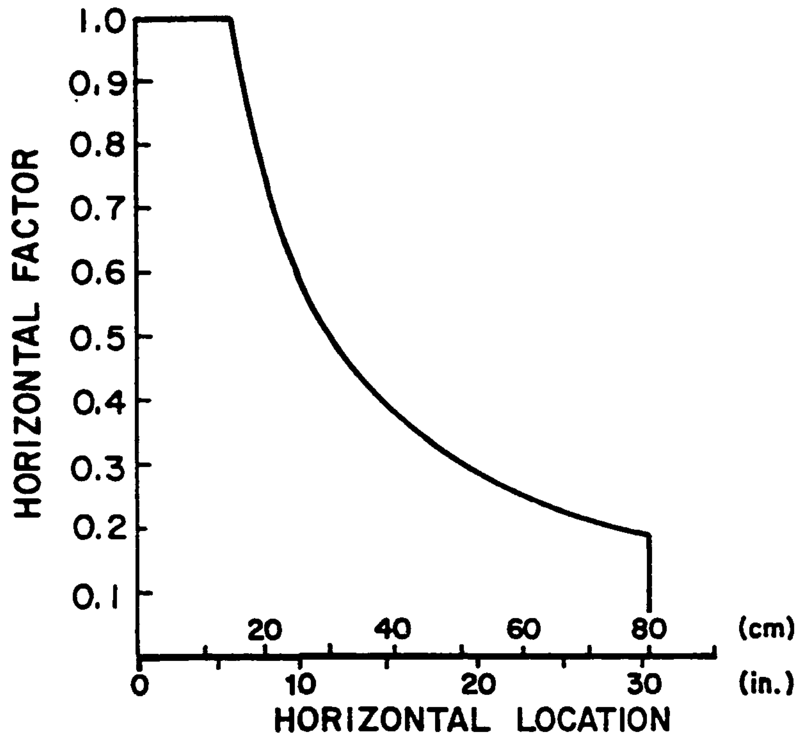


Figure 8.4: Horizontal Factor Nomogram.

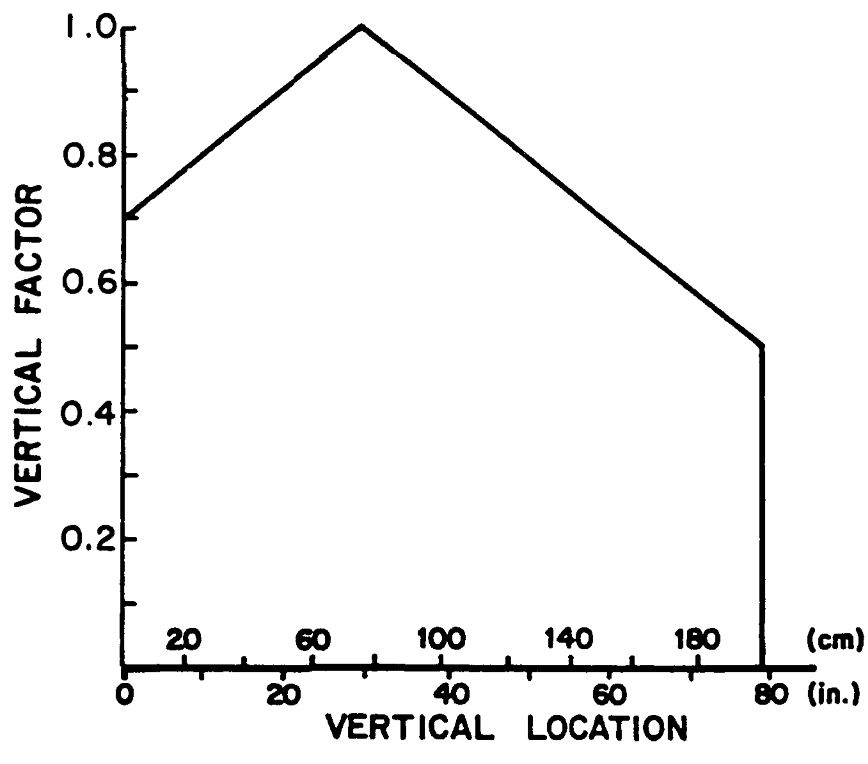


Figure 8.5: Vertical Factor Nomogram.

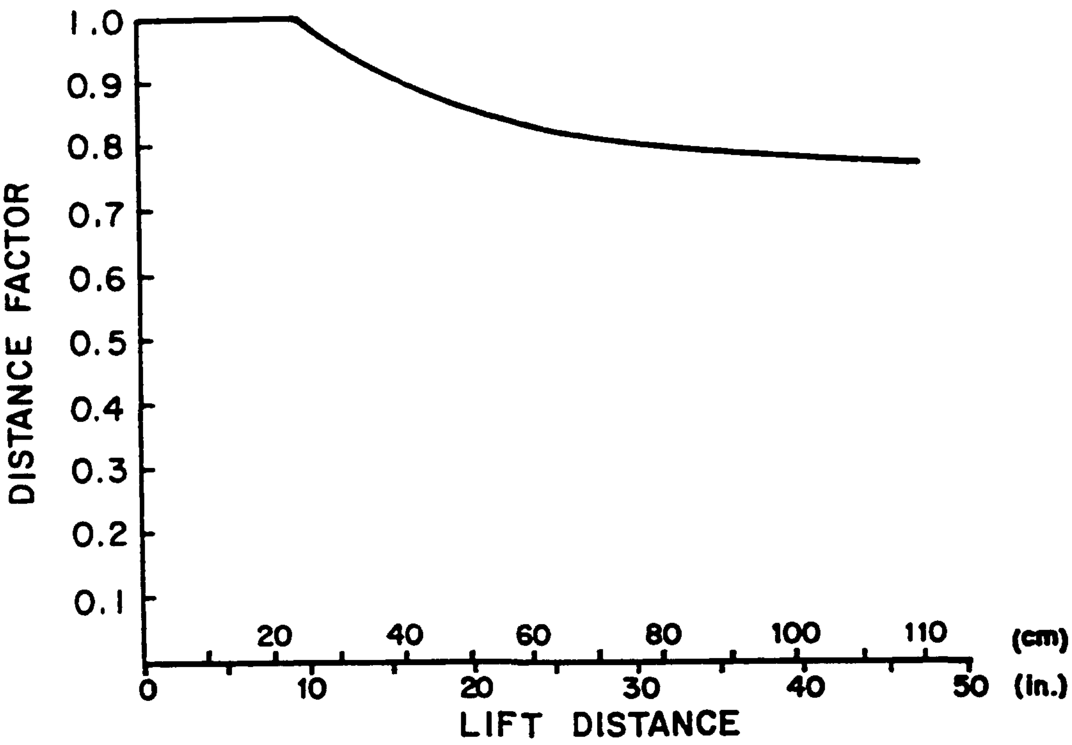


Figure 8.6: Vertical Distance Factor Nomogram.

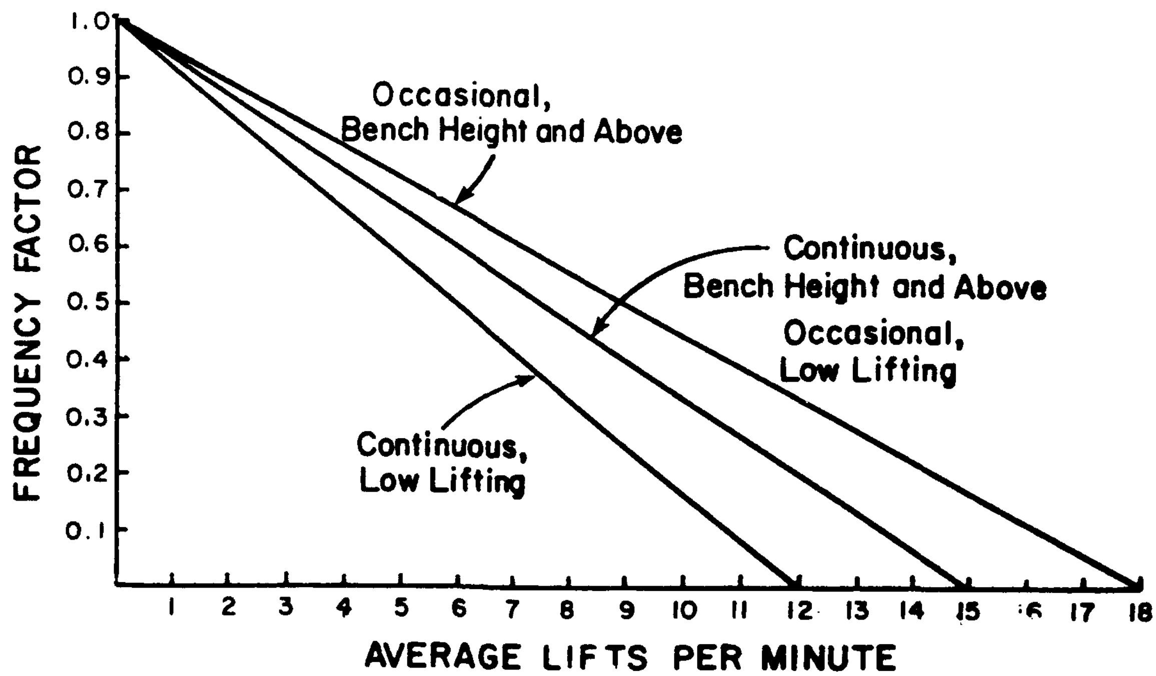


Figure 8.7: Frequency of Lift Factor Nomogram.

analysis sheet. The remarks section may be useful in describing which factor is most restrictive or limiting for each element.

EXAMPLES

Five examples will now be discussed to illustrate the analysis and interpretation of this methodology.

Example 1: Infrequent Lifting

Figure 8.8 illustrates a common misconception (or oversight) in terms of what types of jobs may be physically stressful. A punch press operator, for example, routinely handles small parts, feeding them in and out of a press. A cursory view of this task may overlook the fact that once per shift, the operator is required to load a reel of supply stock (illustrated shoulder height) from the floor onto the machine. The reel weighs 20 kg. This activity is documented in Figure 8.9. Assuming the operator lifts the reel in the plane shown (rather than on the side of the machine) the appropriate horizontal dimension is (75/2 + 15) = 53 cm or $(\frac{30}{2} + 6) = 21$ in. At the destination V = 160 cm (63 in). Since the activity occurs only once per shift, F = 0 (no frequency adjustment required).

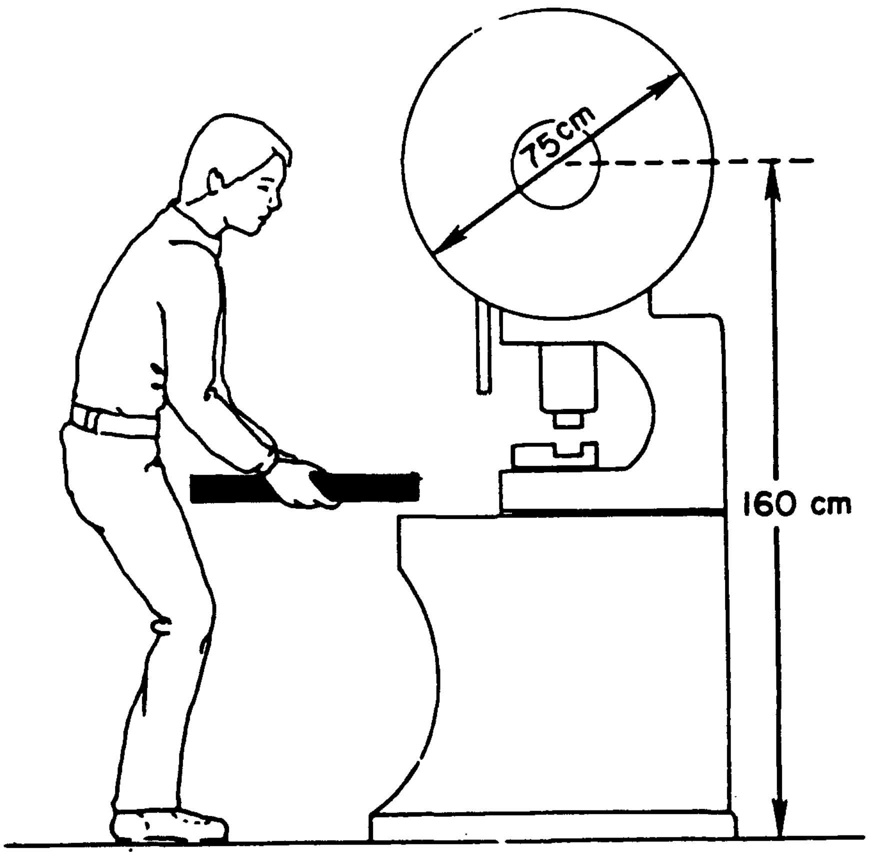


Figure 8.8: Example 1, Punch Press Operator.

PHYSICAL STRESS JOB ANALYSIS SHEET

DEPARTMENT FABRICATION DATE 2/18/80

JOB TITLE PUNCH PRESS ANALYST'S NAME EJB

TASK DESCRIPTION	OBJECT WEIGHT Ave	OBJECT WEIGHT Max	HAND LOCATION Origin H cm	HAND LOCATION Origin V cm	HAND LOCATION Destination H cm	HAND LOCATION Destination V cm	TASK FREQ	AL	MPL	REMARKS
LOAD STOCK	20	20	53	38	53	160	0	7.2	21.6	New Work Practice Needed

Figure 8.9: Job Analysis for Example 1.

Interpreting this activity in terms of the critical variables:

H factor = 15/H = 15/53 = .28

D factor = .7 + 7.5/(160-38) = .76

V factor = 1 - .004 (75-38) = .85

F factor = 1 - 0/15 = 1.0

Therefore

AL = 40(.28)(.76)(.85)(1.0)= 7.2 kg

MPL = 3(7.2) = 21.6 kg

In this case, lifting the 20 kg reel in this way would be stressful for most people and at least strong administrative controls would be required if not engineering controls.

Notice that the H factor is most critical in this case (H factor = .28). If possible, the operator should load the machine from the side (i.e., grasping the reel by its perimeter). This would allow the reel to be brought closer to the body (i.e., H = 20 cm for example). With this preferred work practice,

$$AL = 40(.75)(.76)(.85)(1.0) = 19.4$$

$$MPL = 3(19.4) = 58.2$$

For all practical purposes the activity is now within the capabilities of most people. Alternative engineering controls might include elevating the delivery of reels (above the floor) thus improving both the V and D factors.

Examples 2 and 3: H Not Constant

Evaluation of jobs where the H value is not constant throughout the lift should be approached with caution by the analyst. The most common error is to exaggerate H, making a job seem more difficult than it actually is.

For example, a compact load is lifted from the floor to a point 125 cm high as illustrated in Figure 8.10. Due to workplace constraints the object must be placed on a moving conveyor at a distance H=80 cm but the lift is unconstrained up to waist height (about 100 cm). In most cases, the load can be lifted close to the body up to this point and then through transfer of momentum be placed on the conveyor with little difficulty. Using an H value of 80 cm greatly overestimates the strength requirements of this task. As a general rule of thumb, the analyst should use the H value at the origin (in this case close to the body) to determine the weight limit and not the H value for the end point of the lift. However, a <u>fragile load</u> that must be carefully handled throughout the lift may well require the strength capabilities of lifting the load from the floor to the end point at an H value equal to that of the end point!

The estimation of horizontal location as W/2 + 15 cm for body clearance is not appropriate with horizontal obstructions such as illustrated in Figure 8.11. In this case, the appropriate horizontal dimension is 60 cm at the origin. Presumably the load is not fragile, nor need it be retrieved from the destination. If it must be retrieved the horizontal location at the destination will become the origin for a subsequent lift!

Example 4: Occasional High Frequency Lifting of Constant Weights

Suppose that for a period of one hour, a person unloads palletized cartons each weighing 5 kg stacked 5 high onto a conveyor as illustrated in Figure 8.12. In this case the vertical origin location

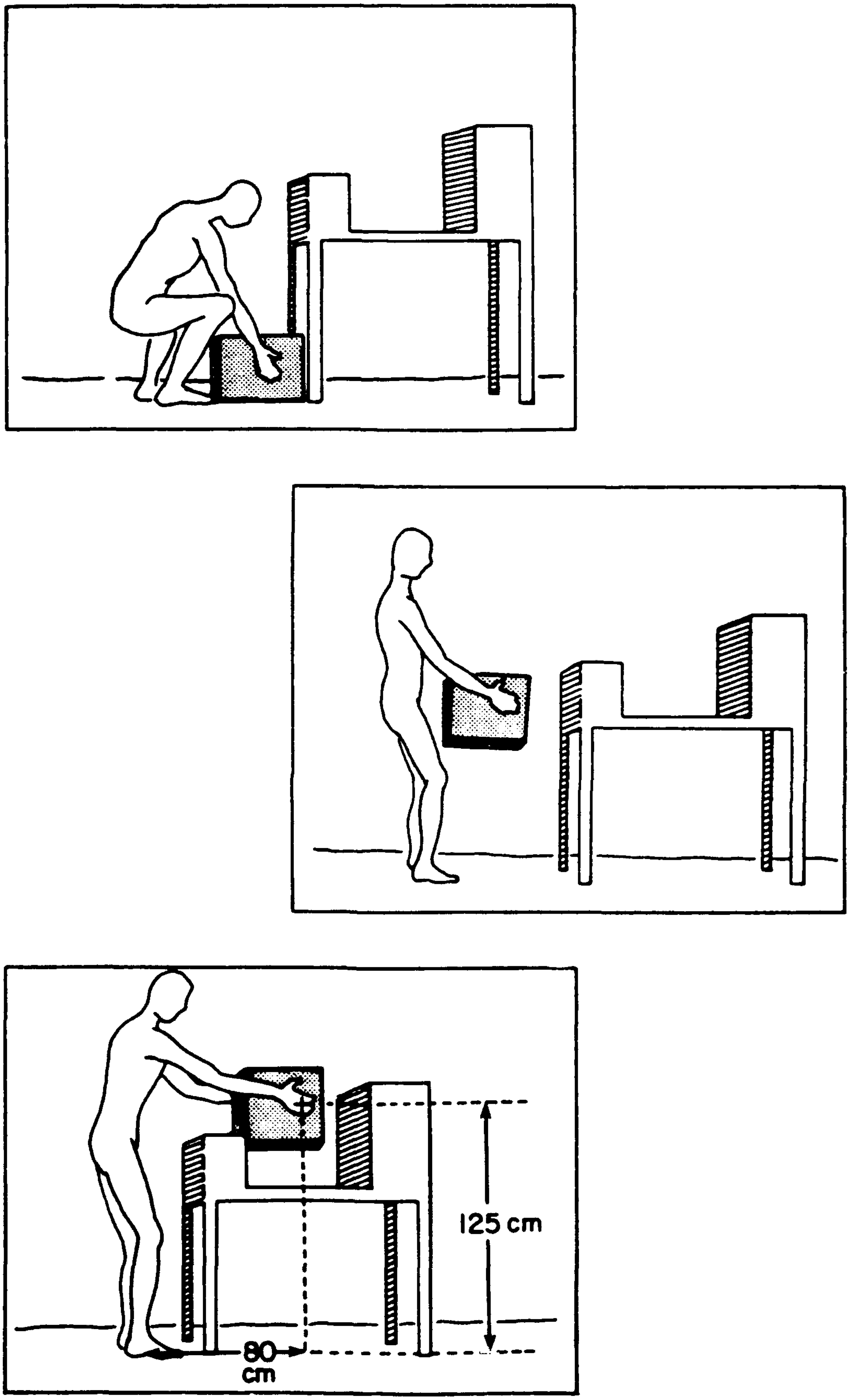


Figure 8.10: Example 2, Transfer of Momentum.

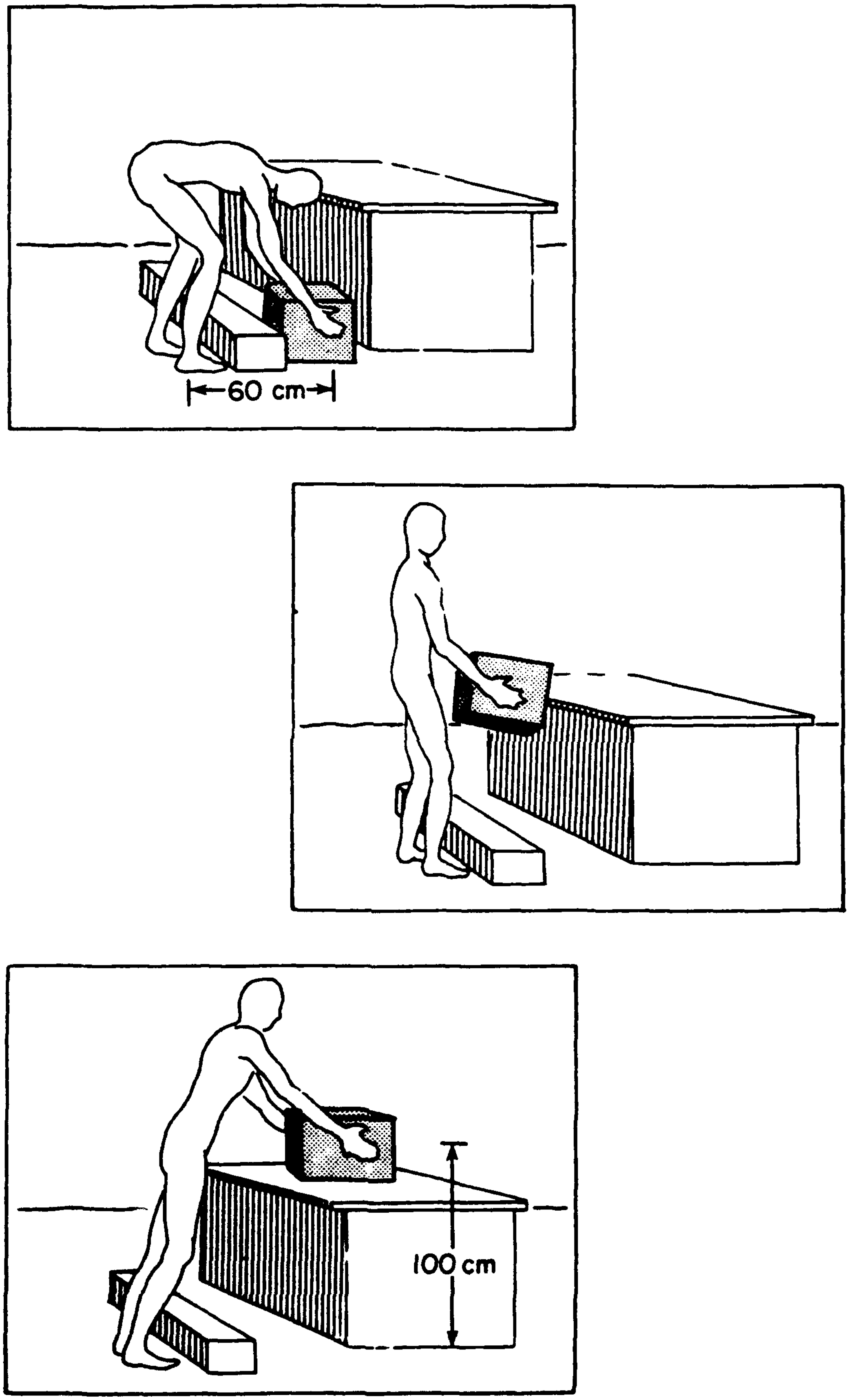


Figure 8.11: Example 3, Horizontal Obstruction.

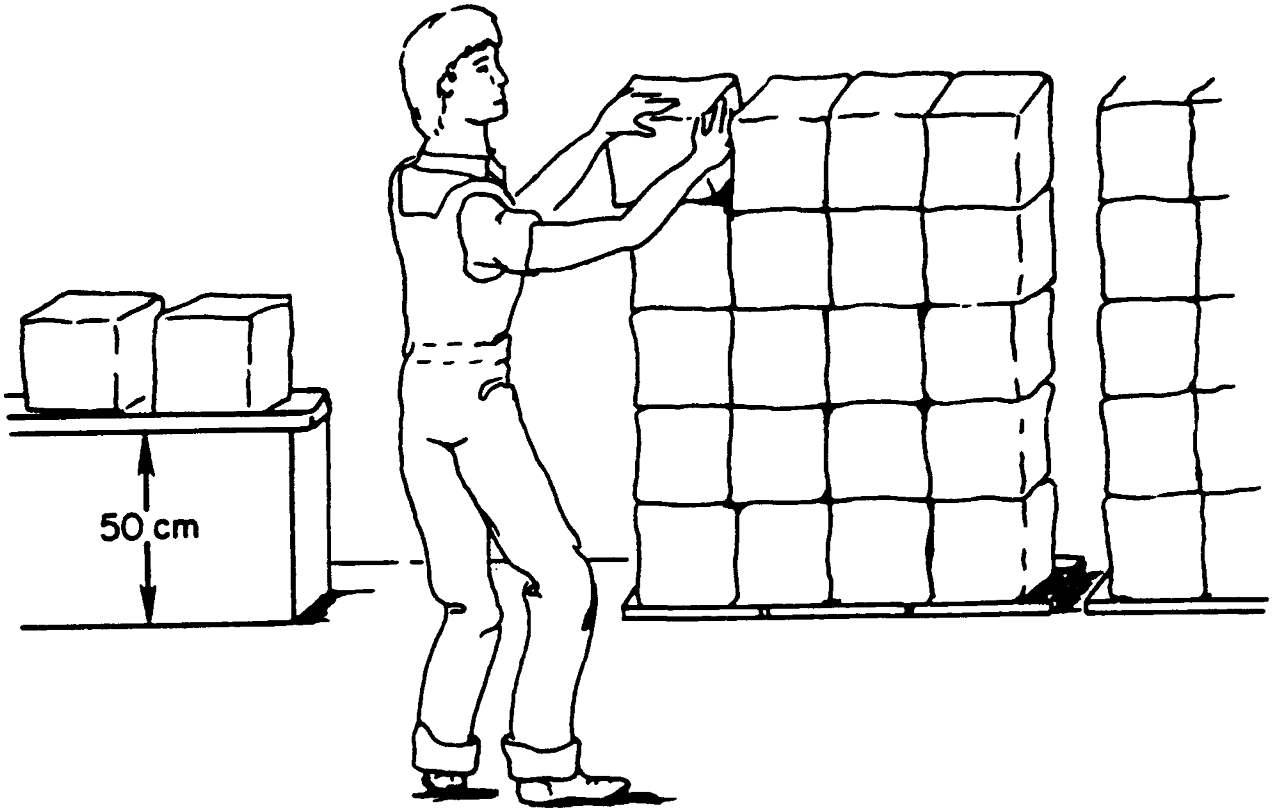


Figure 8.12: Example 4, Depalletizing Operation.

(V) and vertical travel (D) vary from one lift to the next. Also note that this task requires both lifting and lowering (for those high cartons) as well as possibly some twisting and carrying. These later aspects are outside this Guide and their effects should be minimized by a slowed pace for lifting and delivering pallets as close to the conveyor as possible.

Figure 8.13 presents an analysis which approximates the stresses of this activity assuming the carton dimensions are 40 cm x 40 cm x 40 cm, unloaded 12 per minute, and the person is free to climb over the pallet to get close to each carton. Basically the job is divided into 5 tasks representing the 5 tiers of the loaded pallet. The base frequency (12/min) is divided between each tier (2.4 lifts/min/tier). The horizontal location is estimated as H = (15 + 40/2) = 35 cm. The vertical locations at the origin represent the position of the hands under the cartons (ignoring the pallet height for purposes of this example).

Two separate analyses are warranted in this case. Each task should be analyzed separately and then collectively. The most stressful task (or tier) is task 5. For this task the V factor = (1 - .004(160-75)) = .66. The V factors for each of the other tasks will

PHYSICAL STRESS JOB ANALYSIS SHEET

DEPARTMENT WAREHOUSE DATE 8/8/80

JOB TITLE DEPALLETIZING ANALYST'S NAME GDH

TASK DESCRIPTION	OBJECT WEIGHT Ave	OBJECT WEIGHT Max	HAND LOCATION Origin H cm	Origin V cm	Destination H cm	Destination V cm	TASK FREQ	AL	MPL	REMARKS
UNLOAD PALLETS							12/MIN			
TIER 1	5	5	35	0	35	50	2.4			
TIER 2	5	5	35	40	35	50	2.4			
TIER 3	5	5	35	80	35	50	2.4			
TIER 4	5	5	35	120	35	50	2.4			
TIER 5	5	5	35	160	35	50	2.4	8	24	
TOTAL	5		35	80			12	4.7	14	

Figure 8.13: Example 4, Analysis Sheet.

be larger since this vertical origin is most distant from 75 cm. Note that with more complicated tasks such a simplification will not necessarily be possible. It is only possible with this job since all other variables remain constant.

For this most stressful task, then

$$AL = 40\ (15/35)(.66)(.7+7.5/110)(1-2.4/18) = 8\ \text{kg}$$

$$MPL = 3\ (8) = 24\ \text{kg}$$

It is concluded that individually the elements of the job are quite reasonable (5 kg is below the AL).

Now consider the tasks collectively. The following approximation is not exact but should provide a reasonable composite estimate. <u>Derive a weighted average for each variable in the job analysis according to frequency</u>. In this case frequency is constant across tasks and vertical origin and travel distance are the only factors which vary.

The average vertical location is

$$V = \frac{0 + 40 + 80 + 120 + 160}{5} = 80 \text{ cm}$$

The average vertical travel is

$$D = \frac{50 + 10 + 30 + 70 + 110}{5} = 54 \text{ cm}$$

For the total job then

$$AL = 40\ (15/35)(1-.004(5))(.7+7.5/54)(1-12/18)$$

$$= 40\ (.43)(.98)(.84)(.33)$$

$$= 4.7 \text{ kg}$$

$$MPL = 14 \text{ kg}$$

Since the carton weight (5 kg) is nominally above the AL, administrative controls may be required. The analysis suggests that the problem with this job is not so much strength (at issue in the individual task analysis) but endurance. Since a number of simplifying assumptions were made in this analysis a more detailed metabolic analysis of such a job may be warranted before implementing administrative controls. Such an analysis is described in detail by Garg, et al., (1978).

Example 5: Continuous High Frequency Lifting, Variable Tasks

Lifting tasks of this type are typical in warehousing, shipping and receiving activities where there are many different sized loads of varying weights that are lifted at varying frequencies. As a simple example, consider a job with the set of 3 tasks described in Figure 8.14.

For highly variable jobs (such as this one) this Guide is most limited. Following the procedure of the preceding example, each task should first be examined individually. The recommended AL and MPL for each task is as follows:

TASK 1: $AL = 40\ (15/40)(1-.004(75))(.7+7.5/75)(1-1/12)$

$$= 40\ (.38)(.70)(.80)(.92) = 7.8$$

$$MPL = 23.4$$

PHYSICAL STRESS JOB ANALYSIS SHEET

DEPARTMENT Receiving DATE 5/1/80

JOB TITLE Loader ANALYST'S NAME CKA

TASK DESCRIPTION	OBJECT WEIGHT		HAND LOCATION				TASK FREQ	AL	MPL	REMARKS
			Origin		Destination					
	Ave	Max	H cm	V cm	H cm	V cm				
Product A	10	40	40	0	50	75	1	7.8	23.4	Reduce product variability
Product B	15	30	30	0	30	15	2	11.6	34.8	
Product C	5	10	15	75	20	100	5	26.8	80.4	
Total	8.1		22	47			8	7.7	23.1	

Figure 8.14: Example 5, Highly Variable Job.

TASK 2: $AL = 40\ (15/30)(1-.004(75))(.7+7.5/25)(1-2/12)$

$= 40\ (.50)(.70)(1.0)(.83) = 11.6$ kg

MPL = 34.8

TASK 3: $AL = 40\ (15/15)(1-.004(0))(.7+7.5/25)(1-5/15)$

$= 40\ (1.0)(1.0)(1.0)(.67) = 26.8$ kg

MPL = 80.4 kg

Two technical aspects of the above calculations are noteworthy:

a. Travel distances less than 25 cm should be considered as 25 cm. In task 2, this cutoff was used. (Factors must all be less than or equal to 1.0).

b. Since this job is performed continuously, F_{max} factors (from Table 8.2) of 12 and 15 were used for lifts from less than and greater than 75 cm.

Based on this elemental analysis it can be concluded that Tasks 1 and 2 are the most stressful. In fact, the maximum weights of 40 kg (Task 1) are above the MPL = 23.4 and engineering controls (such as mechanical aids or two-person lifting) are warranted. Note that the average weights in Task 1 (10 kg) are reasonable with administrative controls. In both cases, the horizontal location produces the greatest discount in ability. Task 3 appears to be nominal in terms of physical stress.

As with Example 4, analysis of the combined elements of the job can only be approximated by computing weighted averages according to frequency. In this case, the composite

$$H = \frac{1(40) + 2(30) + 5(15)}{8} = 22 \text{ cm}$$

The coefficients 1, 2, and 5 correspond to each elemental frequency and 8 is the total number of lifts per minute.

Similarly, the weighted average

$$V = \frac{1(0) + 2(0) + 5(75)}{8} = 47$$

$$D = \frac{1(75) + 2(15) + 5(25)}{8} = 29$$

$$F = 1 + 2 + 5 = 8$$

Thus, for the combined tasks:

$$AL = 40\ (15/22)(1-.004(75-47))(.7+7.5/29)(1-8/12)$$

$$= 40\ (.68)(.89)(.96)(.33) = 7.7 \text{ kg}$$

$$MPL = 23.1 \text{ kg}$$

Since the average weight lifted is 8.1 kg, administrative controls are required.

It is important to note that this "averaging" of the task descriptors in this case tends to dampen out the large differences between the tasks. This is true in general (but not always). This error and the errors introduced by ignoring other carrying, holding, pushing, and pulling tasks can only be resolved with more detailed biomechanical, metabolic, and psychophysical evaluations.

APPENDIX C

SUGGESTED READINGS IN ERGONOMICS AND

SOURCES FOR TRAINING

SUGGESTED READINGS IN ERGONOMICS

1. U.S. Department of Labor. **Ergonomics Program Management Guidelines for Meatpacking Plants**. Washington D.C.: Occupational Safety and Health Administration, 1990. OSHA Publication No. 3123.

2. The Human Factors Society, Inc. **American National Standard for Human Factors Engineering of Visual Display Terminal Workstations.** Santa Monica CA 90406: P.O. Box 1369, 1988. ANSI/HFS Standard No. 100-1988.

3. NIOSH. **Criteria for a Recommended Standard, Occupational Exposure to Hand-Arm Vibration**. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Division of Standards Development and Technology Transfer, 1989. DHHS(NIOSH) Publication No. 89-106. 1989.

4. Putz-Anderson, Vern. **Cumulative trauma disorders: A Manual for Musculoskeletal Diseases of the Upper Limbs**. Philadelphia: Taylor & Francis, 1988.

5. Tichauer, E.R. **The Biomechanical Basis of Ergonomics**. New York: Wiley-Interscience, 1978.

6. The Ergonomics Group Health and Environment Laboratories, Eastman Kodak Company. **Ergonomic Design for People at Work**. New York: Van Nostrand Reinhold Company, 1986.

7. NIOSH. **Work Practices Guide for Manual Lifting**. Cincinnati OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Saftey and Health, Division of Standards Development and Technology Transfer, 1981. DHHS(NIOSH) Publication No. 81-122.

8. NIOSH. **The Industrial Environment-Its Evaluation and Control.** Cincinnati OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, 1973. Pages 431-492.

9. Grandjean, Etienne, **Fitting the Task to the Man**. New York: Taylor & Francis, 1988.

SOURCES FOR ERGONOMIC TRAINING PROGRAMS

OSHA Training Institute
1555 Times Drive
Des Plaines, Illinois 60018 (708) 297-4913

Washington Technical Training & Design Institute
548 Colecroft Court
Alexandria, Virginia 22314-2146 (703)549-3055

Isernhagen & Associates, Inc.
Isernhagen Work Systems
2202 Water Street
Duluth, MN 55812 (218)728-6455

The Joyce Institute and Associates

Corporate Headquarters
The Joyce Institute
1313 Plaza 600 Building
Seattle, WA 98101 (206) 441-6745/1-800-645-6045

Colorado/Wash. D.C./Baltimore

Ergonomic Mgmt. Systems, Inc.
3891 S. Xanthia
Denver, CO 80237 (303) 220-1164

Conn./Mass./R.I.

Management Development Int'l
560 Russell Ave.
Suffield, CT 06078 (203) 668-6020

Florida

The Joyce Institute
1135 Pasadena Ave. S., Suite 310
St. Petersburg, FL 33707 (813) 345-7090

Illinois

Jaeger Holland
600 Central Ave., Suite 333
Highland Park, IL 60035-3257 (312) 831-6633

Michigan

The Joyce Institute
219 McKinley
Grosse Pointe Farms, MI 48236 (313) 885-5996

Missouri

Komras & Associates
231 S. Bemiston, Suite 800
Clayton, MO 63105 (314) 727-1131

Ohio/Indiana/Kentucky

Purcell Associates
8044 Montgomery Rd., #223
Cincinnati, OH 45236 (513) 984-0759

Oregon/N. California

J and J Consulting
4237 91st SE
Mercer Island, WA 98040 (206) 834-1440

Philadelphia/S. New Jersey

The MBS Group
3111 Spring Mill Road
Plymouth Meeting, PA 19462 (215) 834-1440

Southern States

The Joyce Institute
165 Southwinds, #4
Sanibel, FL 33957 (813) 472-6293

NIOSH Educational Resource Centers

Alabama

The Deep South Center for Occupational and Safety
School of Public Health
University of Alabama at Birmingham
Birmingham, AL 35294 (205) 934-7178 FAX - (205) 975-6341

Illinois

University of Illinois at Chicago
School of Public Health
(M/C 922) 2121 West Taylor Street
Chicago, IL 60612 (312)413-0459

Michigan

Center for Occupational Health and Safety Engineering
1205 Beal Avenue, IOE Building
The University of Michigan
Ann Arbor, MI 48109-2117 (313) 763-2243

Minnesota

Midwest Center for Occupational Health and Safety
St. Paul-Ramsey Medical Center
640 Jackson Street
St. Paul, MN 55101 (612) 221-3992

New York/New Jersy

EOHSI/CET
UMDNJ-Robert Wood Johnson Medical School
45 Knightsbridge Road
Brookwood II
Piscataway, NJ 08854 (908)463-5062

North Carolina

Occupational Safety and Health
Educational Resource Center
University of North Carolina
109 Conner Dr., Suite 1101
Chapel Hill, NC 27514 (919) 962-2101

Ohio

University of Cincinnati
ML 56
Department of Environmental Health
Office of Continuing Education
Cincinnati, OH 45267-0056 (513) 558-1730
FAX - (513) 558-1756

Southern California

Occupational Safety and Health Program Assistant
University of Southern California
3500 South Figueroa, Suite 202
Los Angeles, CA 90007   (213) 743-6383/6523

Texas

Southwest Center for Occupational
Health and Safety
Occupational Marketing, Inc.
11931 Wickchester, Suite 106
Houston, Texas 77043   1-800-869-6783

Utah

Rocky Mountain Center for Occupational and Environmental
Health
Building 512
RMCOEH/University of Utah
Salt Lake City, UT 84112 (801)581-5710

Washington

Northwest Center for Occupational Health and Safety
Department of Environmental Health
University of Washington, SC-34
Seattle, WA 98195   (206) 543-1069

APPENDIX D

EXAMPLES OF ERGONOMIC TOOLS AND EQUIPMENT

This section contains examples of tools and equipment that can be recommended to improve work practices.

The use of brand name product literature does not reflect official endorsement of the Air Force or the Armstrong Laboratory, Occupational and Environmental Health Directorate.

Maintenance, Construction Tools

	Tools	Feature	Model	Manufacturer
1.	Scaling Hammer, Pneumatic	Reduced noise and vibration, long life chisel tip	* 8316	ARO Corp., Bryan, OH
2.	Chipping Hammer, Pneumatic	Reduced noise	* RVM 06 * RRD 37,57	Atlas Copco Farmington Hills, MI
3.	Riveting Hammer, Pneumatic	Reduced noise and vibration	* RRH 10P,105	
4.	Pop Riveter, Hydraulic	Lower Forces, reduced grasp span, one handed use	* Trojan HR 77	Parker Mfg. Co., Worchester, Mass.
5.	Die Grinder Pneumatic	Reduced noise and vibration	* LSF 16/LSV 16	Atlas Copco Farmington Hills, MI
6.	Offset Handle Drill	In-line handle grasp	* LBB 11, 22, 33	
7.	Screwdriver	High torque, triangular shape	* "Power Grip", Model STD	Snap-On Tools, Kenosha, Wisc.
		High torque, racheting spherical handle	* "Easy Driver"	Creative Tools, Inc., Burlington, VT
8.	Ratchet Driver	Improved grasp, restricted space	* Palm Style F 714	Snap-On Tools, Kenosha, Wisc.
9.	Hammers, Claw and Ball Peen	Reduced hand deviation	* "Hand Tastic" Style	Sears Roebuck Co., Chicago, IL

ERGONOMIC HAND TOOLS

The following tools have features which would appear from their design to reduce workplace stressors in some jobs.

Electronic Assembly Tools

Tool	Feature	Model	Manufacturer
1. Sidecutters, Benders, Swagers, Pliers	Reduced grasp span,	* Magic Line BH Series comfort grip	EREM Inc., Torrence, Calif.
	Comfort Grip	* Standard 8000 * Micro Series 3000	Lindstrom Eskilstuna, Sweden (Techni-tool Plymouth Meeting, PA)
	Comfort Grip	* Micro Series 400	Utica Tool Co. Inc., Orangeburg, SC
2. Pneumatic Cutters, Benders	Small, lightweight	* Magic 1500	EREM Inc., Torrence, Calif.
	Small, lightweight	* Jim Dandy MM1, single jaw	Simonds Inc., Southbridge, Mass.
		* Squeeze Eze MSP1, multiple jaws	
	Small, lightweight	* UA 100	Utica Tool Co. Inc., Orangeburg, SC

ANTIVIBRATION GLOVE MANUFACTURERS

VISCOLAS Glove Material
Mr Steve Coakley
GENCO Glove Co.
P.O. Box 231
Chattanooga, TN 37401

800-233-7551

SORBOTHANE Glove Material
Mr Harry Lewis
Sager Glove Co.
65 E. Palatine Road
Prospect Heights, IL 60070

312-541-1361

PORON Glove Material
Mr Dan Pout
Shelby Glove Co
P.O. Box 8735
Grand Rapids MI 49518

800-253-3598

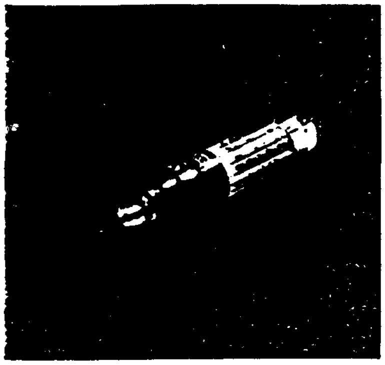
Mr D.J. Stanley
Guard Line Inc
P.O. Box 919
Atlanta TX 75551

800-527-8822

Mr R. Smith
Steel Grip Safety Apparel Co
P.O. Box 747
Danville IL 61832

217-442-6240

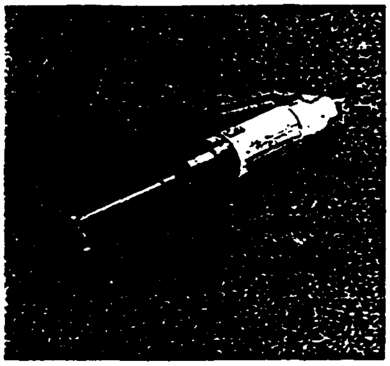
DRILLS



STRAIGHT DRILLS

Intended for vertical drilling operations and for drilling in awkward spaces.
Speed range: 1.300–19.000 r/min.

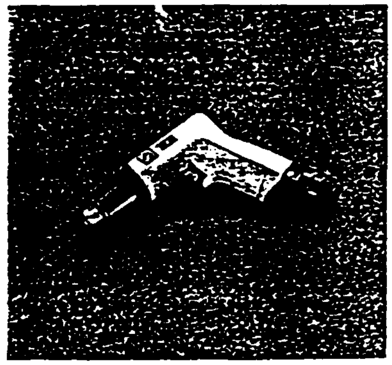
★ Low sound level.
★ Rear exhaust models available.
★ Push-button start available.
★ Lubrication-free.



ANGLE DRILLS

The perfect drill for cramped spaces. Available in versions with 30° and 90° angle heads.
Speed range: 500–4.500 r/min.

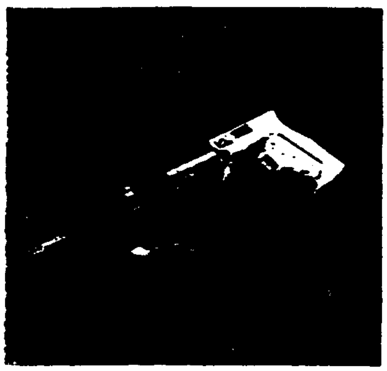
★ Large range of collets.
★ Low sound level.
★ Rear exhaust models available.
★ Lubrication-free.
★ Pushbutton start available.



PISTOL GRIP DRILLS

Suitable for production drilling in virtually every sector of industry.
Speed range: 300–19.000 r/min.

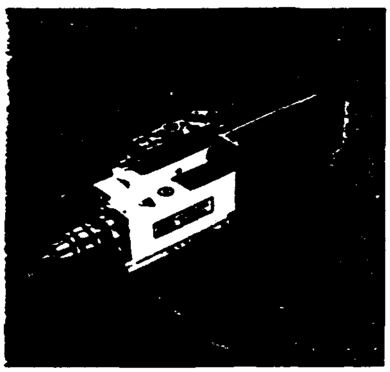
★ Comfortable grip for high precision.
★ Simple and reliable design for long tool-life
★ Exhaust through handle.
★ Lubrication-free.



TAPPERS

Designed for tapping and threadcleaning operations with thread taps.

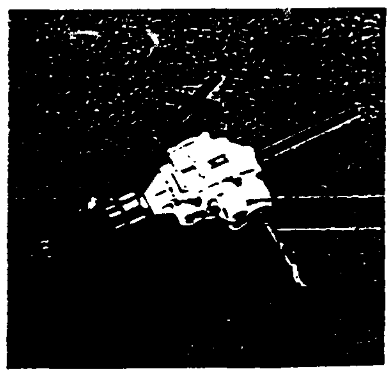
★ Automatic reversing.
★ Double speed when you withdraw the machine.
★ Exhaust through handle.
★ Lubrication-free.



AUTOMATIC DRILLING AND TAPPING UNITS

Available in three sizes covering a diameter range up to 20 mm in steel.

★ Easy to build together for drilling several holes in one operation.
★ Low sound level.
★ Hydraulic damper, chip removal attachments and twin spindle head available as accessories.



SCREW-FEED DRILLS

The ideal tool for heavy-duty drilling operations requiring high feed forces.
Speed range: 140 to 600 r/min.

★ Reversible.
★ Equipped with speed governor for constant speed.
★ Twist throttle with safety catch prevents accidental starting.

PERCUSSIVE TOOLS

RIVETING HAMMERS

Three types suitable for aluminium rivets in diameters up to 8 mm.

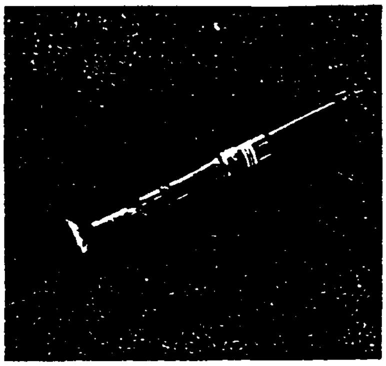
★ Vibration-damped
★ Teasing properties.
★ Adjustable impact force.
★ Adjustable hand guard.
★ Accepts standard rivet sets.

A conventional riveting hammer suitable for cold riveting is also available.

BUCKING BARS

Two sizes can be fitted with several interchangeable dollies and rods for different operations.

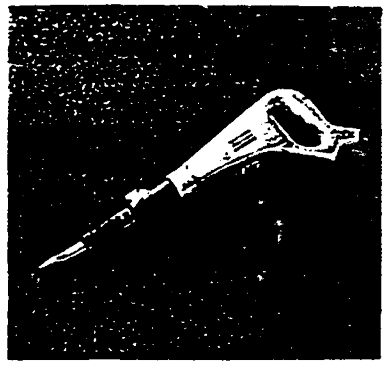
★ Vibration-damped and easy to work with.



RAMMERS

The floor and bench rammers are intended for ramming of casting sand for tamping work etc.

★ Simple and reliable design.

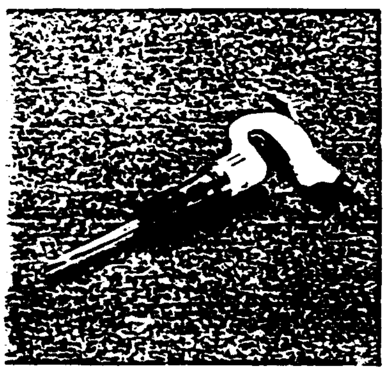


CHIPPING HAMMERS

Two strong and efficient tool series for fettling and chipping operation in foundries and heavy engineering industry.

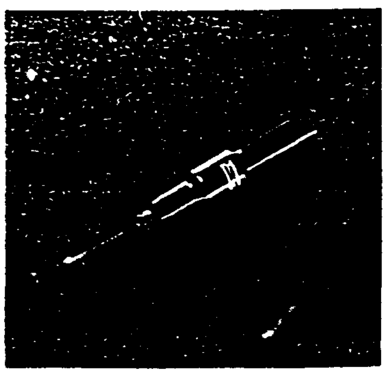
VIBRATION-DAMPED.

★ Low weight.
★ Low sound level
★ Chisel retainer.



CONVENTIONAL

★ Robust and dependable.
★ Available with or without chisel retainer.

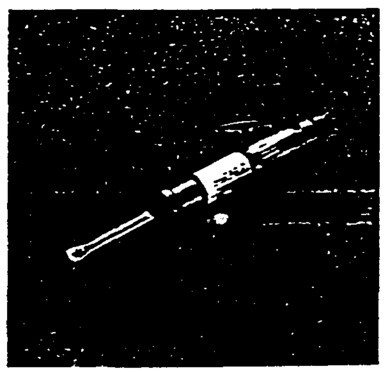


SCALERS

Suitable for weld slag removal as well as light concrete trimming.

VIBRATION-DAMPED.

★ Low sound level.
★ Models with or without clean blowing device.



CONVENTIONAL

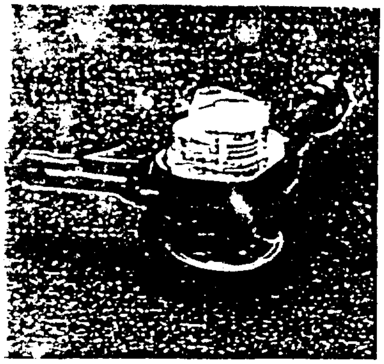
★ High removal rate in relation to its weight
★ Available with or without chisel retainer

NEEDLE SCALER

An effective needle scaler for removing welding slag, cleaning of steel structures etc.

★ Robust design and easy to maintain

Atlas Copco Industrial Tools Inc.
24404 Indoplex Circle, Farmington Hills, Michigan 48018
Telephone (313) 478-5330



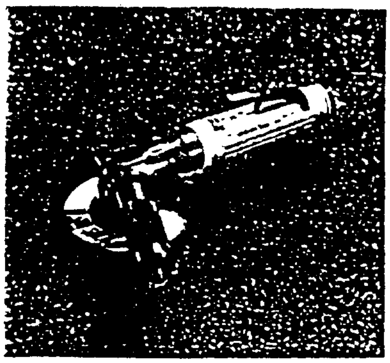
VERTICAL GRINDERS

Strong and efficient tools for heavy-duty operations. Excellent for rough grinding, rust removal and cutting off.

Speed range: 4.500–12.000 r/min.

The new series features.

- ★ Double speed control: governor and independent over-speed shut-off device.
- ★ Low sound and vibration level
- ★ Automatic lubrication.
- ★ Integrated wheel guard.
- ★ Individual adjustment of handle.

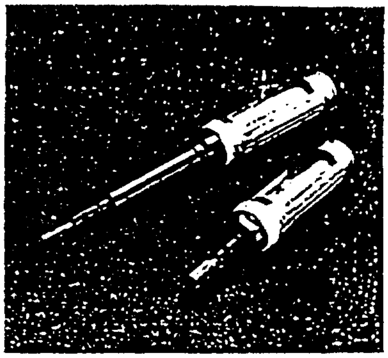


ANGLE GRINDERS AND SANDERS

Angle grinders for depressed centre wheels and low speed angle sanders for coated abrasives for production applications.

Speed range: 1.000–17.000 r/min.

- ★ Governed motor maintains constant speed at variable load.
- ★ Effective sound-damping.
- ★ Rear exhaust and piped-away exhaust air.
- ★ Thermal isolation and safety throttle.

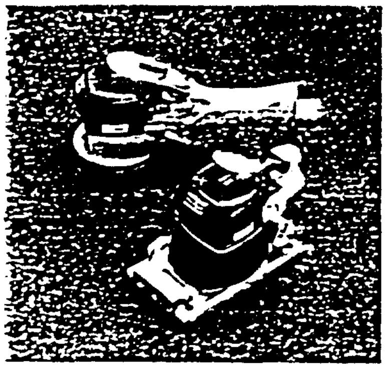


DIE GRINDERS

Designed for mounted points and tungsten carbide burrs. Available in straight or angle versions.

Speed range: 12.000–38.000 r/min.

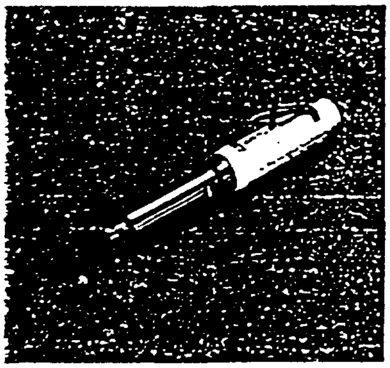
- ★ Governed motor maintains constant speed regardless of load.
- ★ Straight model vibrationdamped for longer life of burrs and operator comfort.
- ★ Rear exhaust and piped-away exhaust air.
- ★ Thermal isolation and safety throttle.
- ★ [illegible] collet for low run out and [illegible] grip.



ORBITAL AND RANDOM ORBITAL SANDERS

Ideal for most production sanding to smooth surface of coated or non-coated sheet metal. Wet and dry sanding. Standard, self-suction and central dust suction models.

- ★ Lightweight and low vibrations.
- ★ Palm grip or handle.
- ★ Safety throttle and finger protection.
- ★ Speed setting device.

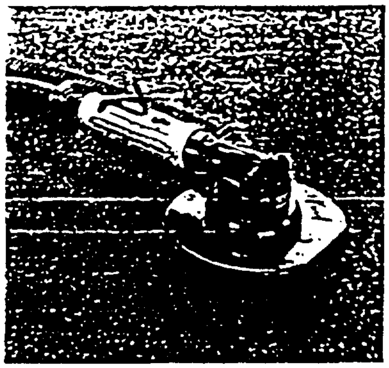


STRAIGHT GRINDERS

A robust all-round tool covering a wide range of applications from deburring to rough grinding.

Speed range 4.100–18.000 r/min.

- ★ Speed-governed motor ensures good grinding economy.
- ★ Vibration-damped. (26 and 36 series)
- ★ Safety throttle.

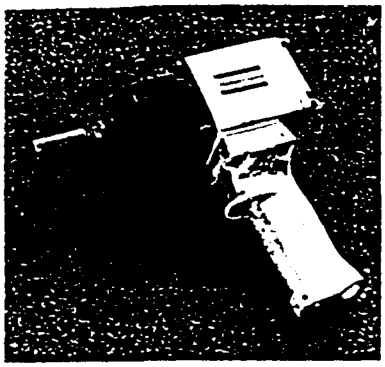


ACCESSORIES

A great number of accessories are available such as spot suction equipment, backing sets for various applications etc.

Atlas Copco Industrial Tools Inc.
24404 Indoplex Circle, Farmington Hills, Michigan 48019
Telephone (313) 478-5320

ASSEMBLY TOOLS



IMPACT WRENCHES

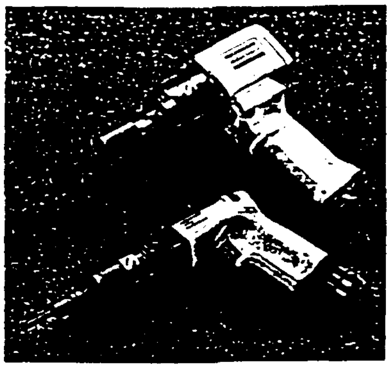
Suitable for general assembly and disassembly in heavy industrial production.

M6–M45 bolt capacity.

★ Fast tightening and disassembly with powerful and fast air motor.

★ Minimum or no reaction torque and low weight.

★ Well-balanced impact mechanism with low vibration level.



HYDRAULIC IMPULSE NUTRUNNERS

Suitable for high torque accuracy in serial production.

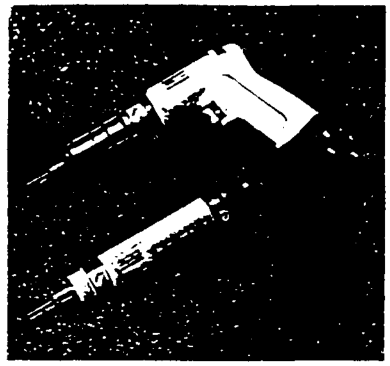
M5–M16 bolt capacity.

★ Fast accurate tightening and no reaction force.

★ Low sound and vibration levels.

★ Long service life.

★ Lubrication free.



SCREWDRIVERS

A complete range of more than a hundred pneumatic screwdrivers. Straight, pistol-grip or angle head models. With slip clutch, direct drive or shut-off torque control.

Screw size M1.2–M6.

Torque 0.1–20 Nm.

★ Accurate torque regardless of joint hardness/stiffness due to the air shut-off torque control.

★ Low weight and comfortable grip.

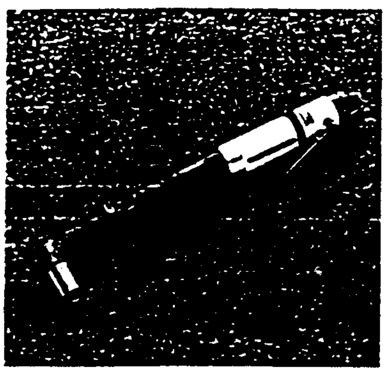
★ Low sound and vibration levels.

★ Lubrication-free.

Atlas Copco Industrial Tools Inc.

24404 Indoplex Circle, Farmington Hills, Michigan 48018

Telephone (313) 478-5330



ANGLE NUTRUNNERS

Suitable for very high torque accuracy and close-ranged applications.

The range includes models such as: stall type, torque control type, crowfoots, worm drive and ratchet type

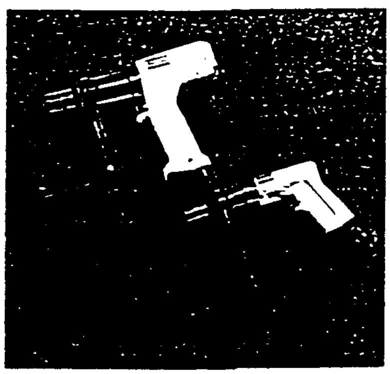
M2.5–M14 bolt capacity.

★ High torque accuracy

★ Independent of joints hardness stiffness.

★ Low reaction forces due to the fast clutch

★ Good accessibility due to small dimensions



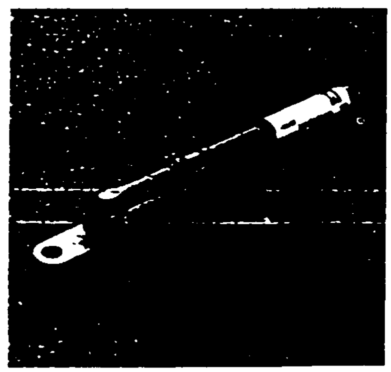
PISTOL GRIP NUTRUNNERS

Lightweight tools with reaction bars, stall type or shut-off type. Available also for counter-clockwise rotation and prevailing torque fixings.

★ High torque accuracy.

★ Twin-motor offers fast rundown and accurate tightening.

★ Reaction bar prevents transmission of reaction forces to the operator.



TOOLS FOR SPECIAL APPLICATIONS

Customer-adapted fastening tools for special applications such as:

★ Straight nutrunners with torque control for single and multiple tightening.

★ Angle nutrunners with built-in paint marking or with integrated socket.

★ Angle nutrunners with built-in torque transducer and/or angle encoder.

★ Crowfoot nutrunners.

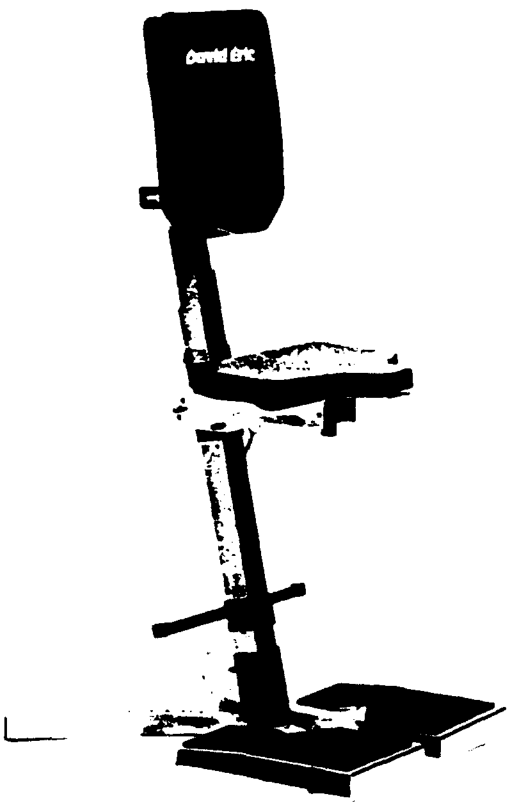
★ Nutrunners for hold and drive bolts

The WorkStand™

David Eric™

universal ergonomic support stand

WorkStand Universal Ergonomic Support Stand reduces forces which can lead to chronic muscle fatigue and cumulative trauma disorders of the back and legs for persons who must stand and/or lean continuously. By providing a unique support system to the torso and lower body, The WorkStand allows the user to work freely for extended time periods in any of six comfortable vocational postures. The WorkStand easily reconfigures to permit regular changes in usage modes during the work day, facilitating multiple positioning, a key ergonomic work place enhancement. Primarily built of aluminum for strength, light weight, and corrosion resistance, The WorkStand provides a wide range of dimensional and angular adjustments to accommodate most users. The WorkStand is a product of David Eric's commitment to quality...designed to deliver years of satisfying work enhancement.



The WorkStand™ *Biomechanical Technical Briefing:*

Standing-Upright Leaning Forward Position: The upright standing posture with a moderate leaning forward addresses a variety of vocational tasks, particularly in the manual material handling category. The WorkStand's chest support pad which can be adjusted to suit individual needs and convenience counterbalances some of the moments caused by the weight of the torso with respect to the lumbar spine. In turn, the tone in the dorsal muscles of the spine is relieved and the risk of cumulative trauma disorders in this region diminishes. The knee support allows a moderate knee flexion which acts two-fold: 1. the stability of the knee is enhanced without the fatiguing effect of alternating activity of the quadriceps and hamstrings; and, 2. the relative laxity in the hamstring muscles obviates redundant tension and relieves unnecessary forces to be exerted on the hip and lumbar spine.

Standing-Upright Leaning Backward Position: The upright standing posture with a moderate backward leaning is aimed at assisting in the performance of manual material handling in the upper quarter-sphere of the work space. In this posture the originally designated chest pad serves as an adjustable back support. This moderate backward inclination reduces lumbar extensors activity by relying primarily on the alignment of the weight line of the torso (to reduce the lever arm relative to the lumbar vertebrae) rather than on counterbalancing. This constitutes a natural approach towards posture correction which necessitates a minimal reliance on the active support of the pads. Tension in the cervical extensors and the deltoid is also reduced by shifting the head weight line, thus reducing fatigue.

Standing-Deep Leaning Forward Position: The deep leaning posture is one of the most harmful vocational postures from the standpoint of cumulative trauma disorders. The WorkStand addresses this posture by providing chest and abdominal support in a semi-prone position of the torso. Most of the weight of the upper body is born by the chest, and despite the abnormal configuration of the lumbar lordosis, the spine is subjected to relatively small forces. The knee supports provide further relief by permitting the knees to flex slightly and reduce hamstring tension which is otherwise substantial.

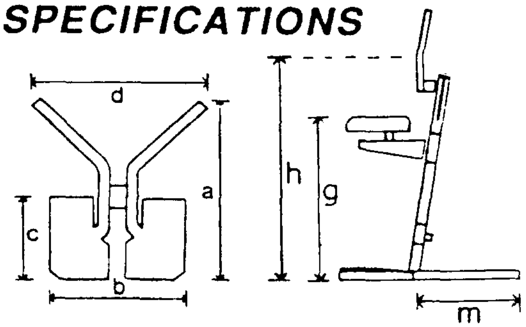
Sitting-Upright Leaning Forward Position: The sitting posture with a slight forward tilt of the torso is aimed at the performance of tasks in a limited space in the upper range of the lower quarter-sphere. In this position, the chest pads are playing a major supporting role since, by virtue of the job requirements, the lumbar lordosis is enhanced and the line of gravity is pushed forward. This increases the torque exerted on the lumbar vertebrae and the compression on the intervertebral disks. The only way to alleviate these loads is by supporting the chest as done by The WorkStand.

Sitting-Upright Leaning Back Position: This ergonomic sitting posture resembles conventional sitting with a back support with one exception: the special design of the seat pad leaves the thighs unsupported. This causes most of the weight bearing to be carried out by the ischial tuberosity at the distal pelvis (on a small area) and permits considerable knee flexion. By virtue of this intentional instability of the ischial support, the user leans lightly backwards to stabilize his trunk and reduces considerably the loads on the lumbar spine. Furthermore, the permission of knee flexion creates hamstring laxity which also contributes to additional alleviation of the lumbar muscle tone.

Sitting-Extreme Leaning Back Position: The quasi-supination permitted by The WorkStand is aimed at the performance of overhead tasks. The back and ischial tuberosity serve as the main load carriers and therefore the spine is almost entirely relieved from axial stresses. An extra feature provided particularly for this posture is the headrest pad which relieves the cervical spine from the head weight bearing and reduces neck tension. Furthermore, due to the nature of the posture and the relative position of the arms with respect to the trunk, the demand for deltoid muscle activity is smaller compared with the equivalent standing posture. This also contributes to the reduction of neck muscle fatigue.

Should your requirements call for special materials or designs, David Eric welcomes custom engineering requests.

SPECIFICATIONS



Dimensions:	Materials:	
a= 27.5	Main Structure:	anodized aluminum
b= 18"	Brackets:	nickel plated steel
c= 11.75"	Cushioning:	self skin, vinyl covered foam
d= 23"		
g= min. 20"	Capacity:	300 lb person
max. 31"		
h= min. 34.5"	Adjustments:	
max. 48"	Seat	height, tilt, extension
	Chest/Back Pad	height,60° radial tilt, extension
m=13.75"	Footrest	height
Weight= 29 lbs	Headrest	optional

REPRESENTED BY

David Eric.

David Eric Design, Inc.
1220 Valley Forge Road, Valley Forge, Pennsylvania 19481
Toll Free (800) 441-4741 (215) 896-2180 FAX (215) 642-1372

CATALOG NUMBERING INDEX—ALL ANGLE AIR ERGO-SERIES

HOUSING AND AIR MOTORS	R.P.M.	CHUCKS	CLUTCHES
2S1 127.00 Right-Hand Rotation	1 61.00 1000 R.P.M.	O "O" Represents Omission of Chuck When Clutch is Used	O "O" Represents Omission of Clutch When Chuck is Used
2S2 145.00 Reversible	2 61.00 1600 R.P.M.	1 22.00 1/4" Jacobs	1 55.00 Direct Clutch 1/4" Hex Female Screwdriver
2SX1 152.00 Right Hand Rotation with Remote Exhaust	3 61.00 2200 R.P.M.	3 25.00 3/8" Jacobs Available on 1000 1600 & 2200 R.P.M. Units Only	1M 81.00 Direct Clutch Magnetic 1/4" Hex Female Screwdriver
2SX2 170.00 Reversible with Remote Exhaust	4 75.00 3500 R.P.M. Not Available With Clutches or Reversible Tools	4 20.00 1/4" Sioux Collet Not Available on Reversible Tools	2 81.00 Direct Clutch 1/4" Square Male Nut Runner Optional 3/8" Square Male
	5 75.00 5000 R.P.M. Not Available With Clutches or Reversible Tools		3 65.00 Positive Clutch 1/4" Hex Female Screwdriver
			3M 91.00 Positive Clutch Magnetic 1/4" Hex Female Screwdriver
			3Q 60.00 Positive Clutch 1/4" Hex Female Screwdriver Quick Change Chuck
			4 85.00 Positive Clutch 1/4" Square Male Nut Runner Optional 3/8" Square Male
			5 125.00 Adjustable Clutch 1/4" Hex Female Screwdriver
			5M 150.00 Adjustable Clutch Magnetic 1/4" Hex Female Screwdriver
			5Q 140.00 Adjustable Clutch 1/4" Hex Female Screwdriver Quick-Change Chuck
			6 140.00 Adjustable Clutch 1/4" Square Male Nut Runner Optional 3/8" Square Male
			7 46.00 Stall Drive 1/4" Hex Quick-Change Chuck Screwdriver
			9 175.00 Depth Locator Available in "S" Series Positive Clutch Only

ALL TOOLS ON THIS CHART ARE CODE J

EXAMPLE:

2S-1—Right Hand Rotation	127.00
3—2200 R.P.M.	61.00
O—Represents Omission of Chuck When Clutch is Used	
3—Positive Clutch 1/4" Hex Female Screwdriver	65.00
Tool No. 2S-1303	**253.00**

Years of Innovation

ORDERS AND INQUIRIES (800) 798-6451
FAX (800) 798-7329

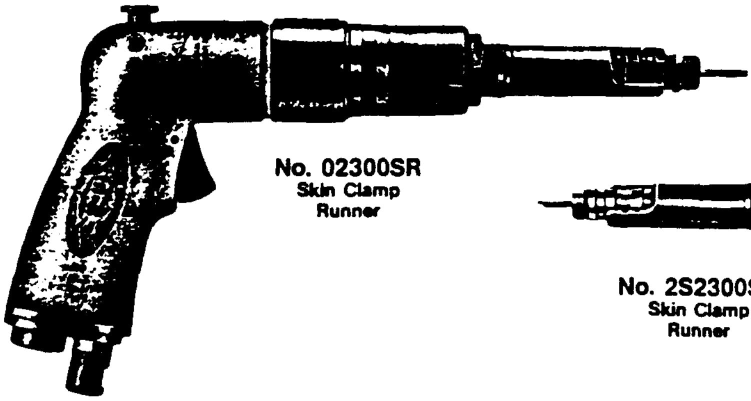
SIOUX TOOLS INC.

2901 FLOYD BOULEVARD ■ SIOUX CITY IOWA 51102 ■

PRINTED IN THE U.S.A
FORM 2‑29 9/89

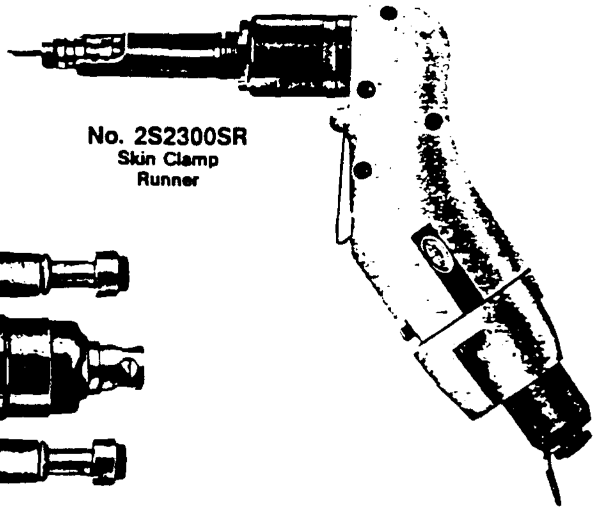
Aircraft Specialty Tools—Rivet Shaver, Flathead Drill, Skin Clamp Runners

NEW

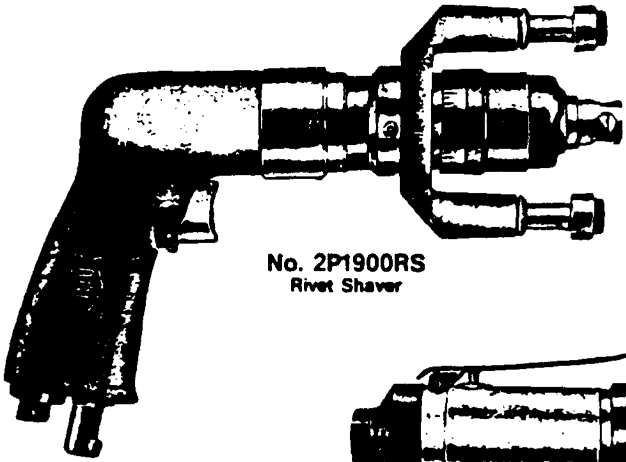


No. 02300SR
Skin Clamp Runner

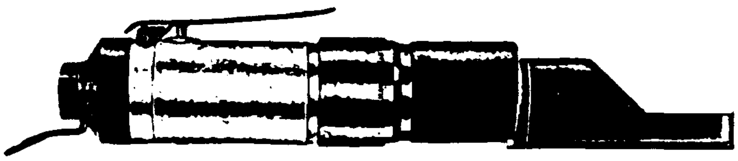
"Skin Clamp" not included



No. 2S2300SR
Skin Clamp Runner



No. 2P1900RS
Rivet Shaver



No. L1300FD
Flathead Drill

- Ergonomically designed housings
- .33 or .8 horsepower
- Spare parts compatible with other Sioux Air Tools
- Rapid reverse on 02300SR Skin Clamp Runner

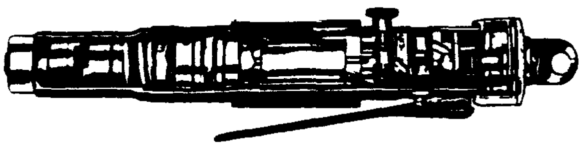
Description	Handle		R.P.M. No Load	Capacity	Cat. No.	Side To Center Inches	Spindle Thread (Female)	Hose Conn.	Min. Hose Size	Overall Length Ins.	Net Wt. Tool Only Lbs. Oz.
Flathead Drill	Lever	NR	2,500	[illegible]	L1300FD	33/64	1/4"-28	1/4"	1/4"	10-5/8	2-4
Rivet Shaver	Pistol	NR	18,000	••	2P1900RS		1/4"-28	1/4"	3/8"	8-5/8	3-2
Skin Clamp Runner	S Handle	Rev	2,200	[illegible]	2S2300SR	29/32	[illegible]	1/4"	1/4"	5-11/16	2-10
Skin Clamp Runner	Pistol	Rev	1,900	•	02300SR	29/32	—	1/4"	1/4"	9-1/8	2-9

••Cutter capacity 1/2" std., 5/8" max.

• w/1/2"-12 point internal hex
9/16"-6 point external hex

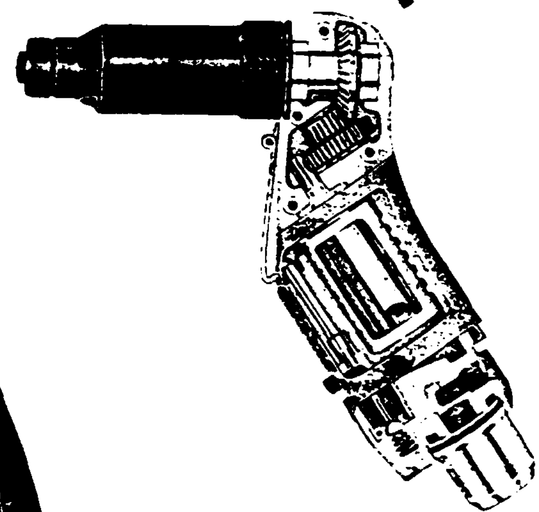
Other RPM variations available upon request.

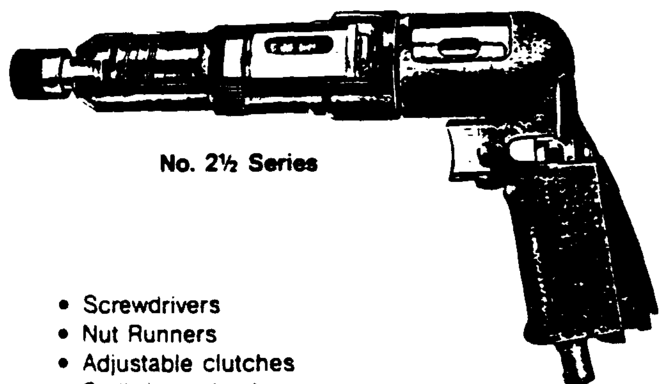
Assembly Tools and Accessories Air and Electric



No. 1 Series

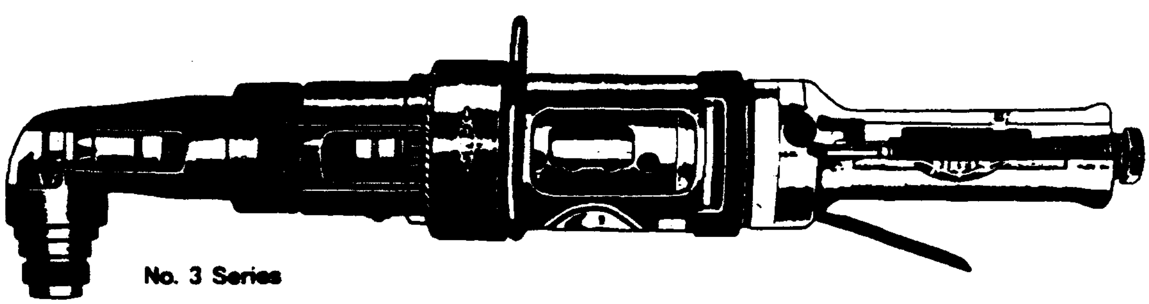
2S Series NEW





No. 2½ Series

- Screwdrivers
- Nut Runners
- Adjustable clutches
- Stall drive clutches
- Direct drive clutches
- Depth locator clutches
- Reversible
- Non-reversible



No. 3 Series

PALLETPAL™

Manual Pallet Unitizer

Rugged tubular steel frame rated for loads in excess of two tons.

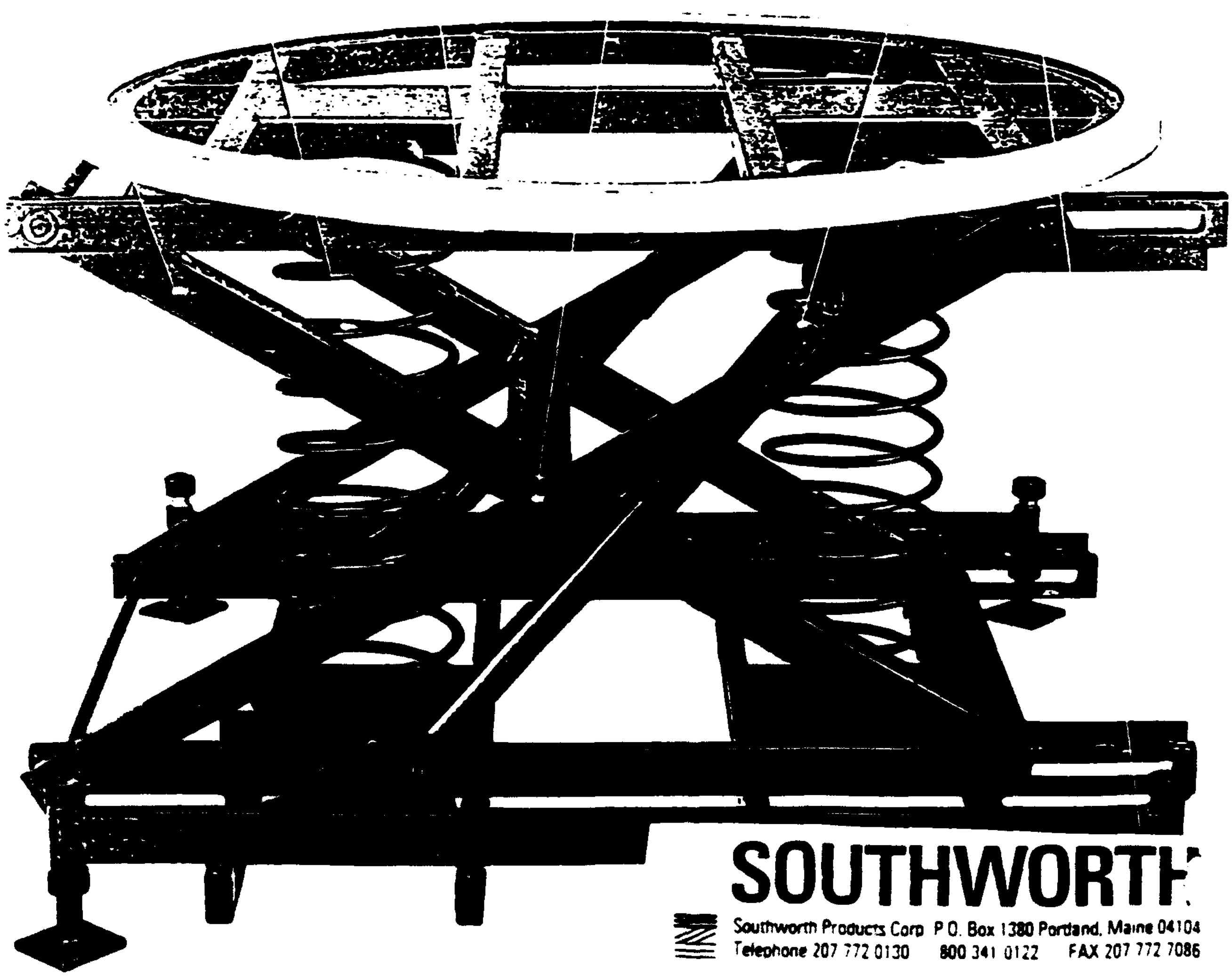
Heavy-duty springs calibrated to bring pallet to most convenient loading and unloading height.

Low-friction bearing-supported turntable for near-side loading and unloading.

Proven linkage design maintains level pallet surface even under uneven loading.

Shock absorbers provide smooth, gradual raising and lowering action without overshoot or spring bounce.

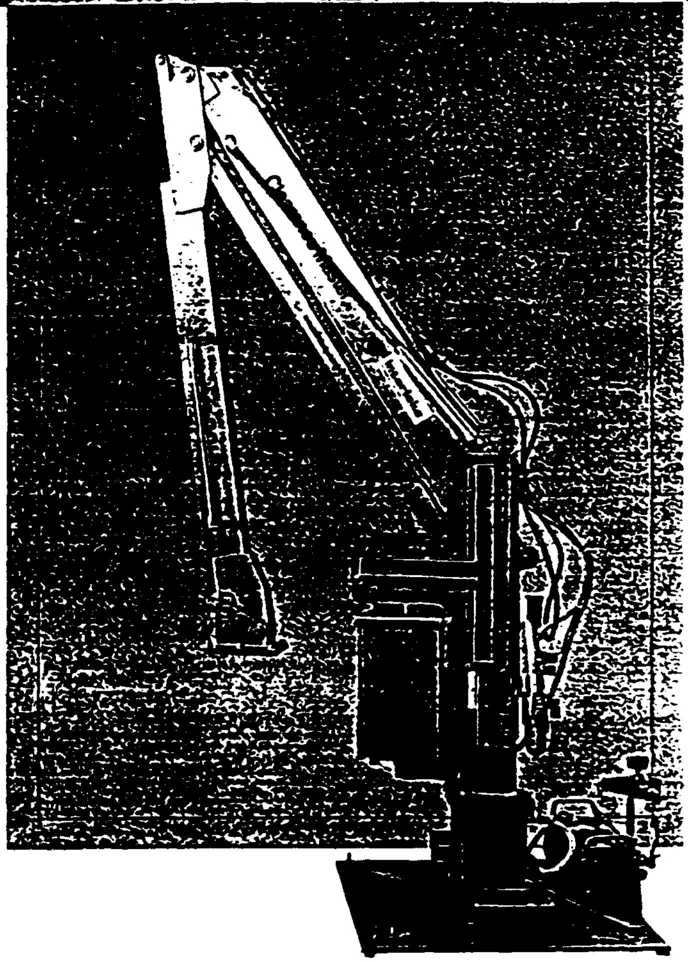
Leveling feet allow use on sloping or uneven floors.

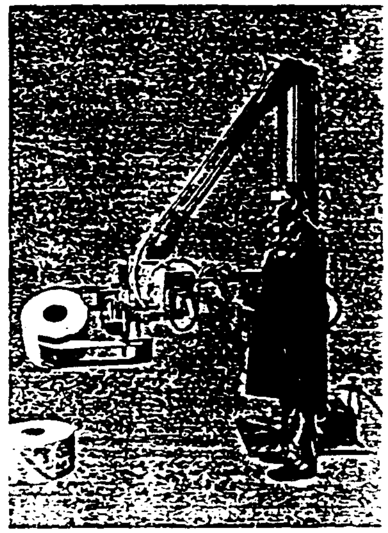


SOUTHWORTH

Southworth Products Corp P.O. Box 1380 Portland, Maine 04104
Telephone 207 772 0130 800 341 0122 FAX 207 772 7086

CONCO CLEARANCE MASTER





The Conco Clearance Master™ is a low-headroom manipulator that has been designed and developed to perform in work areas with low overhead limitations; even as low as 8 feet. Now, the need to reconstruct the work area for the purpose of improving handling is eliminated. With the Clearance Master tight overhead restrictions that might ordinarily prohibit use of manipulators are no longer a problem.

The Clearance Master features parallelogram construction and pneumatic controls. And, like the Balance Master, this manipulator can be floor mounted or overhead mounted. The Clearance Master also shares all of the same unique handling capabilities and outstanding features of the Balance Master. It is available with a choice of controls and a variety of custom-designed, end of the arm tooling or hooks. Maximum protection for the operator and the product are built-in through carefully integrated safety systems.

Model Number	Maximum Capacity lbs. (kg)	Radius of Reach ft. (m)
CLEARANCE MASTER (Operates on clean, dry, shop air, 90 psi)		
CM300-8P	300 (135)	8 (2.4)

To convert to ceiling mount change suffix on Model to C

1-800-561-1644

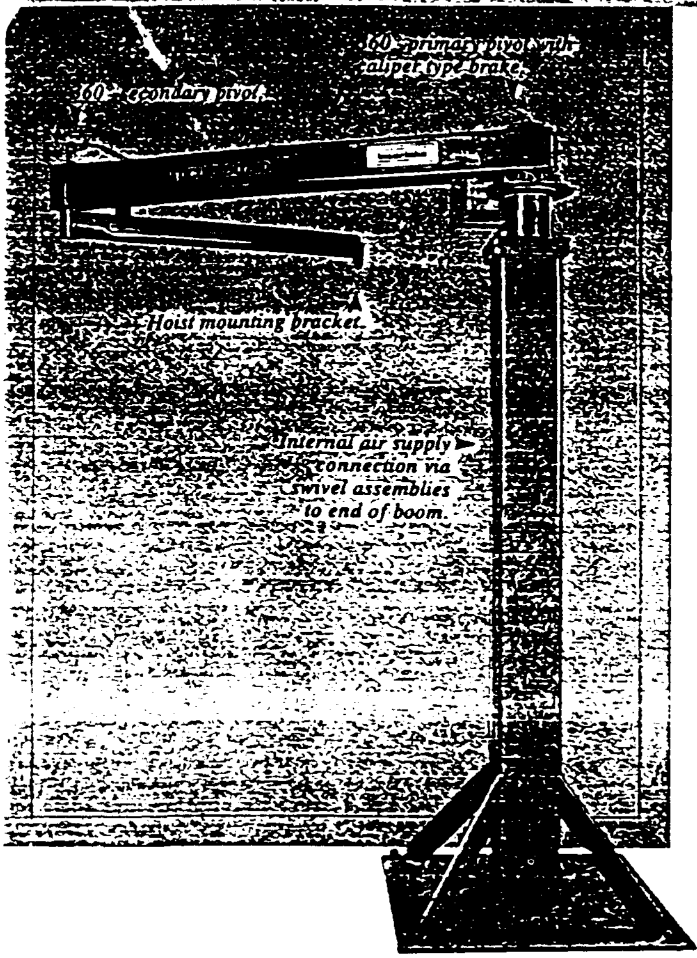
Conco Manipulator Products™

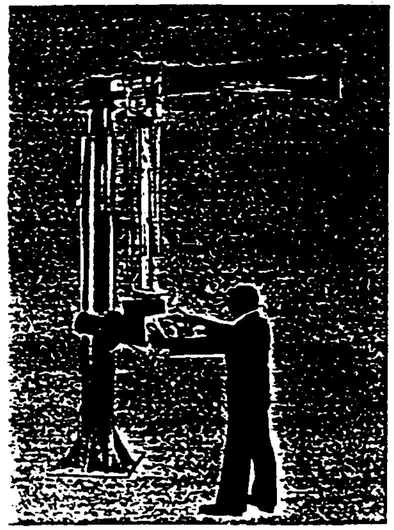
Manufactured by LSE Machinery

100 McLean Court

Concord, Ontario L4K3L5, Canada

CONCO ARTICULATED JIB CRANE





Special Articulated Jib Crane with customized airlift and tooling.

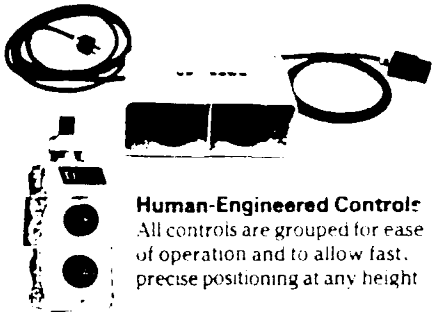
The Conco Articulated Jib Crane™ provides flexibility and lateral maneuverability within a work area up to 32 feet in diameter. This special Articulated Jib Crane differs from ordinary jib cranes because it utilizes two 360° pivot arms that enable it to reach into confined areas where standard jib cranes cannot operate.

As a floor mounted unit or overhead mounted unit, the Articulated Jib Crane is especially practical for assembly line operations where lateral movement along a conveyor is needed, where space is limited, or where loads or objects are heavy or awkward. It serves overhead or floor functions with a smooth, flowing action. It provides for free, horizontal movement, requiring minimal operator effort regardless of load position within the working radius. And, its internal pneumatic piping makes it ideal for lifting devices such as the Conco Airlift.

Model Number	Maximum Capacity lbs. (kg)	Radius of Reach ft. (m)
MINI SERIES *(Standard Pedestal 90")*		
AJ310-8P	310 (141)	8 (2.4)
AJ280-9P	280 (127)	9 (2.7)
AJ250-10P	250 (114)	10 (3.0)
AJ230-11P	238 (108)	11 (3.3)
AJ210-12P	210 (96)	12 (3.6)
AJ190-13P	190 (86)	13 (3.9)
AJ180-14P	180 (82)	14 (4.2)
AJ170-15P	170 (77)	15 (4.5)
STANDARD SERIES *(Standard Pedestal 98")*		
AJ1250-8P	1250 (569)	8 (2.4)
AJ1110-9P	1110 (505)	9 (2.7)
AJ1000-10P	1000 (455)	10 (3.0)
AJ910-11P	910 (414)	11 (3.3)
AJ835-12P	835 (380)	12 (3.6)
AJ770-13P	770 (350)	13 (3.9)
AJ715-14P	715 (325)	14 (4.2)
AJ666-15P	666 (302)	15 (4.6)
HEAVY DUTY SERIES *(Standard Pedestal 98")*		
AJ2000-8P	2000 (910)	8 (2.4)
AJ1785-9P	1789 (814)	9 (2.7)
AJ1600-10P	1600 (728)	10 (3.0)
AJ1460-11P	1460 (664)	11 (3.3)
AJ1340-12P	1340 (609)	12 (3.6)
AJ1236-13P	1236 (562)	13 (3.9)
AJ1150-14P	1150 (523)	14 (4.2)
AJ1071-15P	1071 (487)	15 (4.5)
AJ1000-16P	1000 (455)	16 (4.8)

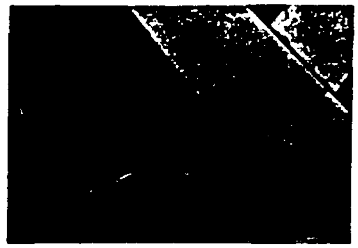
To convert to ceiling mount change suffix on Model to C.

Heavy-Gage Steel: Submerged-Arc Welded
All Southworth lift tables are built for rugged industrial service with heavy structural steel components and submerged-arc weldments

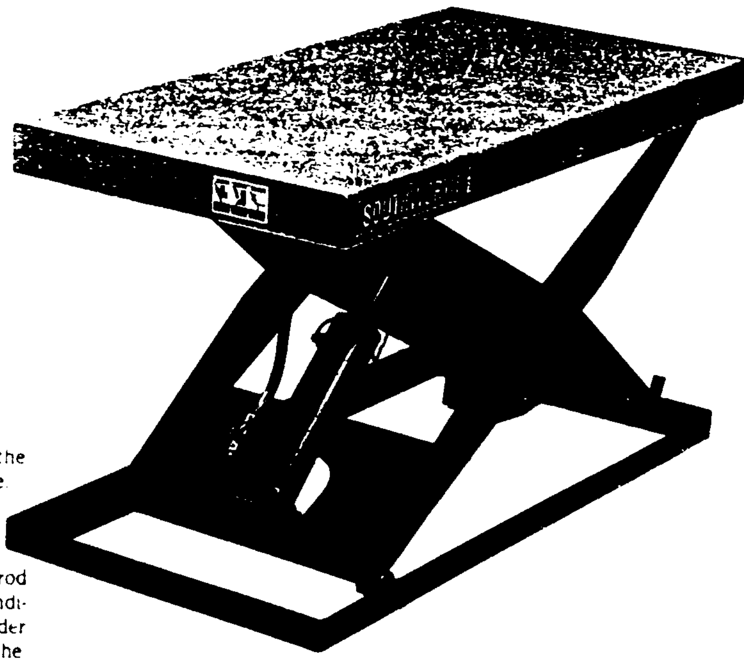


Human-Engineered Controls
All controls are grouped for ease of operation and to allow fast, precise positioning at any height

Lubricated-for-Life Bearings
All pivot points have hardened and ground pins that operate in lubricated-for-life, virtually maintenance-free bushings.



Contoured Legs
With extra width at the pivot point Southworth's contoured legs combine great strength with lower collapsed height.



LIFT LITE Specifications

Platform Size: 24" × 48"
Base Frame Size: 24" × 48"
Lowered Height: 6¼"
Vertical Travel: 35"
Elevated Height: 41¼"
Capacity: 1,500 lbs uniform load

Options

Portable with spotter
Portable without spotter
Casters with floor lock
Bellows safety guard *
Safety stop bar*
Oversize (30" × 54") platform

*Oversize platform must be specified with these options
All specifications and dimensions subject to change without notice
Prices FOB factory

Heavy-Duty Hoses and Fittings
All Southworth lifts have heavy-duty hoses with burst strength 350% greater than the hydraulic operating pressure.

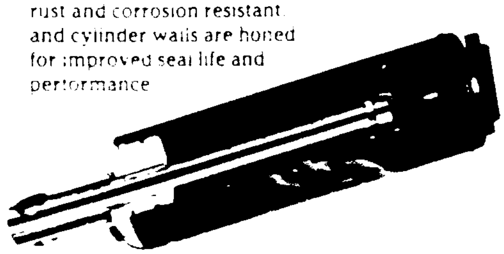
Tell-Tale Return Hydraulic Fluid Line
Clear plastic return line from rod bearing to tank gives visual indication of need to repack cylinder and prevents fluid spillage in the event of a bypass.

Flow Control
Adjustable, pressure-compensated flow control valve with lock out.

Heavy-Duty Torque Tubes
Torque tubes minimize twisting and deflection for high degree of rigidity and stability

Machine Shipped Complete
Machine, power unit, controls and hydraulic fluid are all shipped fully assembled

Oversize, Low-Pressure Hydraulic Cylinder
Low operating pressure extends the life of the cylinder and other components. Hard chrome-plated piston rods are rust and corrosion resistant and cylinder walls are honed for improved seal life and performance

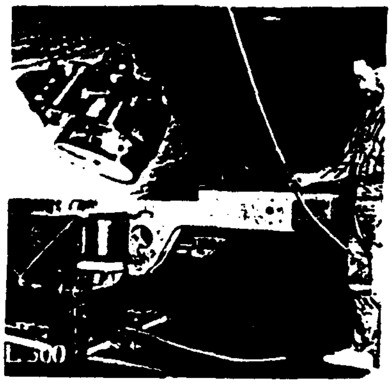


Southworth Products Corp
Eastern Mall Park
P O Box 1380
Portland, Maine 04104 5001
Telephone [illegible]
800 [illegible]
FAX [illegible]

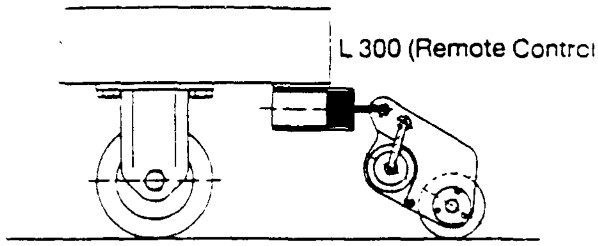
SOUTHWORTH

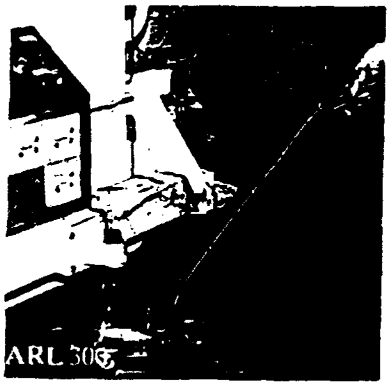
Easy Mover Model Pusher

For Special Applications

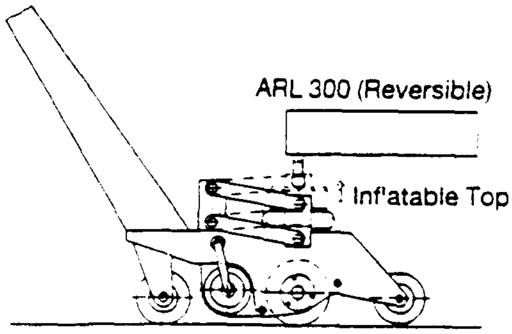


Line cars for
chassis, 8 tons
Bus assembly plant
Volvo AB





Roller mounted
stamping machine,
10 tons
Paper container
industry
Tetra Pak AB



TECHNICAL DATA

MODEL:	Force applied	Maximum speed	Weight	Air pressure	Air volume
L 300 (Remote control)	660 lbs	75 ft/min	18 lbs	85 psi	23 cfm
ARL 300 (Reversible)	660 lbs	65 ft/min	40 lbs	85 psi	23 cfm

Easy Mover is a powerful, easy-to-use tool for moving and handling heavy materials and objects weighing up to fifty tons single handed.

The task of moving aircraft in confined areas is simplified with ***Easy Mover.*** The Swedish Air Force is currently using ***Easy Mover*** in maintenance and service operations... The pneumatically driven ***Easy Mover*** features a smooth, variable speed adjustment for precise operator control at speeds up to one hundred and ten feet per minute...

The conventional labour intensive method of handling large diameter paper rolls in the pulp and paper industry can be eliminated with ***Easy Mover.***

Easy Mover
Revolving Technologies, Inc.
P O. Box 61208, Sunnyvale
California 94088-1208, USA
Telephone: (408)745-1044
Telex: 346352
Fax: (408)734-9012

Rugged, heavy duty plastic rollers provide a gripping action with an applied force up to 3300 pounds on any dry rolling surface.

Just connect the air hose and heavy objects are instantly moved without any physical effort. In many applications the labor costs are drastically reduced...

Easy Mover is currently being used by many multi-national companies involved in the manufacturing maintenance and service for all types of products ranging from vehicles, aircraft, heavy machinery, paper products, railway cars, boilers and cable reels to food processing equipment.

Aero-Motive
A Woodhead Industries, Inc Company

Balancer Basics

TOTAL LOAD — When selecting a balancer, first consideration should be given to the weight of the total load to be balanced (tool plus cable or hose plus other attachments). When the total weight has been determined, the balancer model with the proper tension (weight range) can be chosen. All Aero-Motive balancers have an external device for "on-the-job" tension adjustment. The adjustment range for each model is specified in the selection tables.

BALANCER MOUNTING — For maximum operator efficiency and balancer life, the tool balancer should always be mounted directly over the work area, with the cable perpendicular to the floor when in use. Working with the load *not* perpendicular causes operator fatigue and excessive wear on balancer cable and drum. When it is necessary to continually move the balancer and tool from one position to another a system of **trolleys** and **runways** can be used.

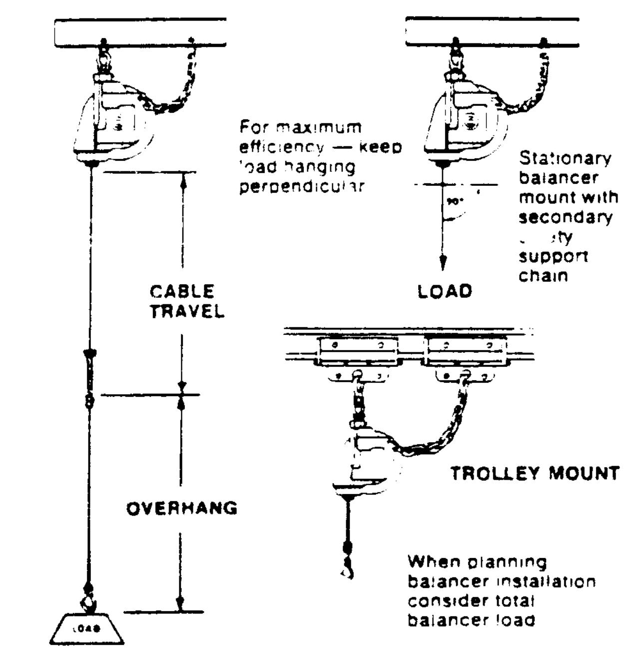
CABLE TRAVEL — Cable travel is the total length of cable which can be installed on and pulled out of a balancer.

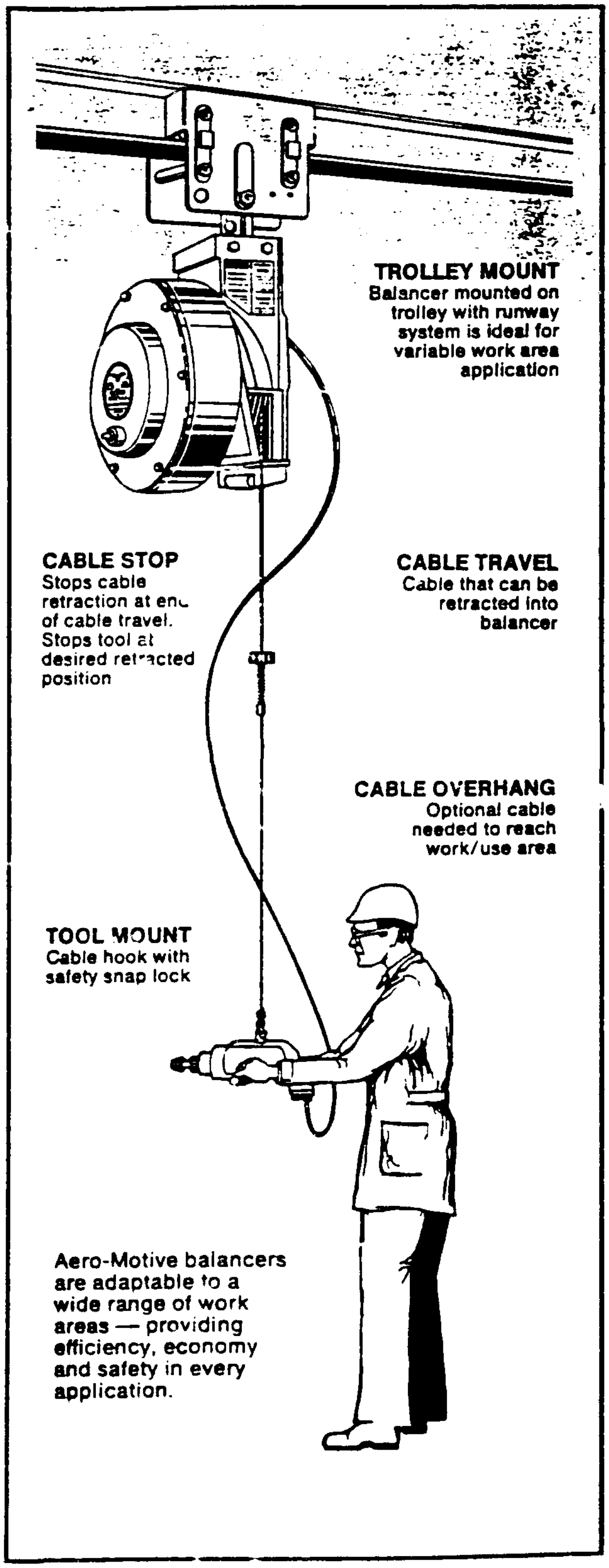
CABLE OVERHANG — Cable overhang is any additional length of cable attached to or part of the active cable, which is not retracted into the balancer. Overhang cable is often necessary for work areas with high ceilings.

SECONDARY SUPPORT CHAIN — It is strongly recommended that all balancers mounted overhead have a secondary support chain attached, to prevent the possibility of the balancer accidentally falling. The chain attaches to the balancer with the other end attached to a support other than the one that supports the balancer.

See pages 16-22 for Work Stations.

BALANCER APPLICATION TIPS

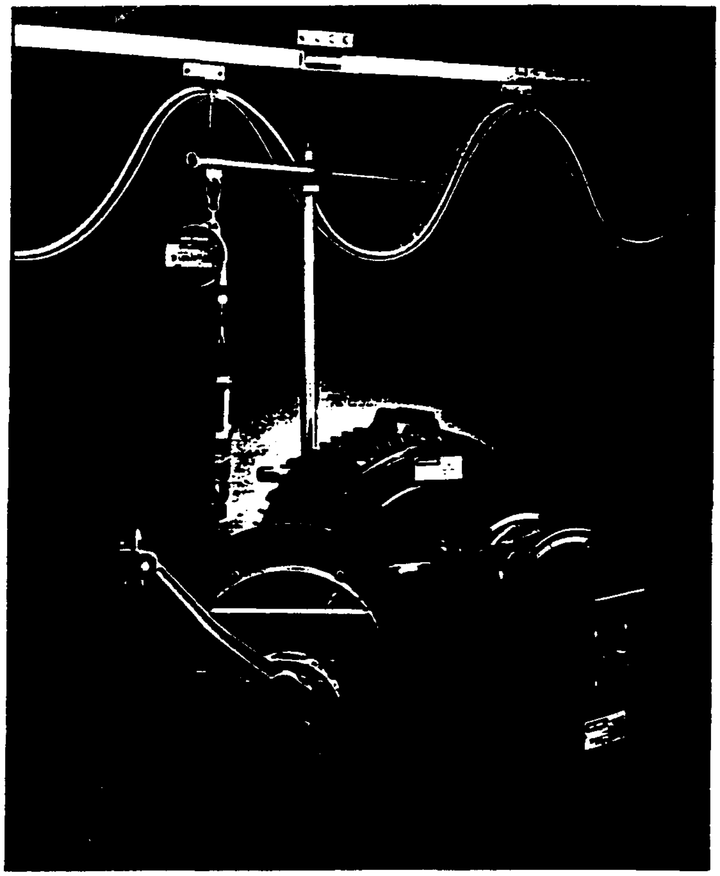


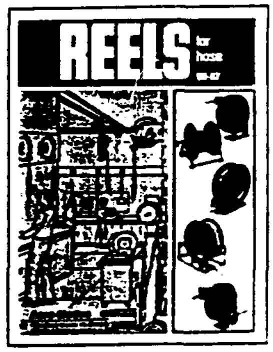


Aero-Motive

A Woodhead Industries, Inc. Company

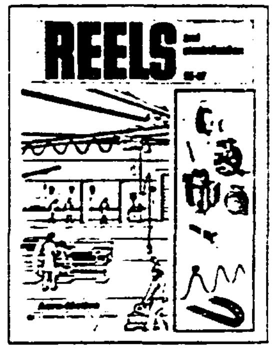
AERO-MOTIVE products have, over a number of years, earned an enviable reputation for long-life performance and rugged dependability. Experienced craftsmanship and the most modern manufacturing methods and materials available combine to assure quality and trouble-free service. The catalogs illustrated below cover the extensive line of Aero-Motive "job-proven" products for industry. For free copies of catalogs, or product information, contact us...**ask the leader!**





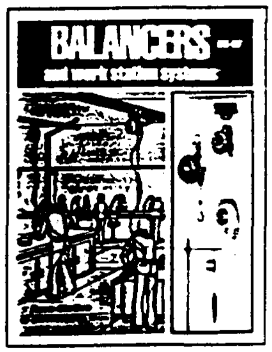
HOSE REELS

Hose Reels for a wide range of applications from standard industrial to specialized hydraulic and pneumatic equipment.



ELECTRIC CORD REELS AND ELECTRIFICATION SYSTEMS

Electric Cord Reels and Festooning, Aero-Trak and Pow-R-Feed systems for crane and machine tool electrification.



BALANCERS AND WORK STATION SYSTEMS

Complete line of Tool Balancers for portable tools, jigs, and pendent stations; and versatile Work Stations adaptable to any work area situation.

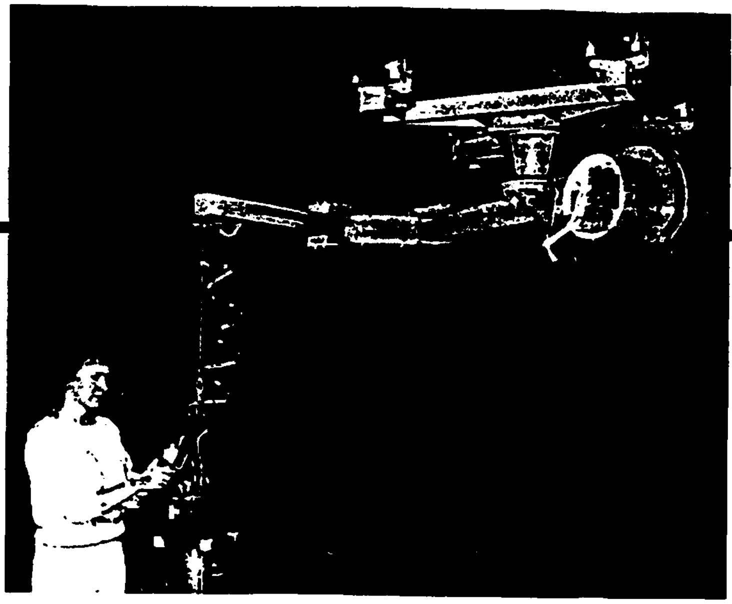
AERO-MOTIVE LOCATIONS

U.S.A.
AERO-MOTIVE
P.O. Box 2678
Kalamazoo, MI 49003
Ph. (616) 381-1242
Telex: US 224420
FAX (616) 381-1081

CANADA
AERO-MOTIVE
1090 Brevik Place
Mississauga, Ontario
Canada L4W 3Y5
Ph. (416) 624-6518
Telex: 06-965530
FAX (416) 624-9151

UNITED KINGDOM
AERO-MOTIVE U.K. LTD.
Rassau Industrial Estate
Ebbw Vale Gwent NP3 5SD
United Kingdom
Ph. 495-305-436
Telex: 497 392
FAX 495-301-877

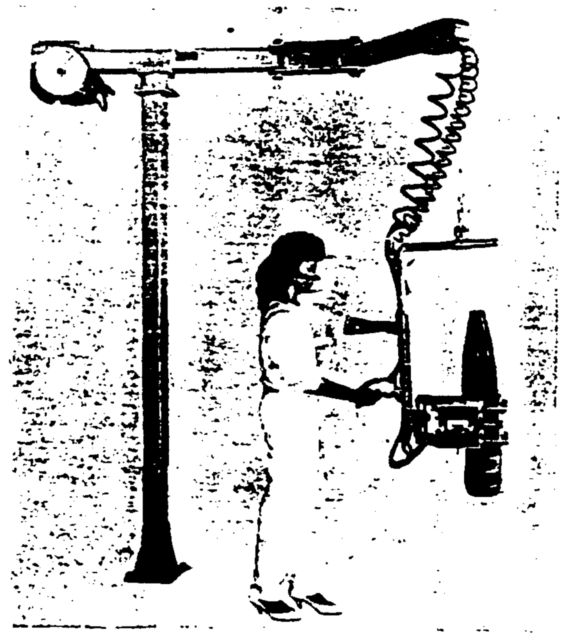
DB-69R GIL 10M 1189



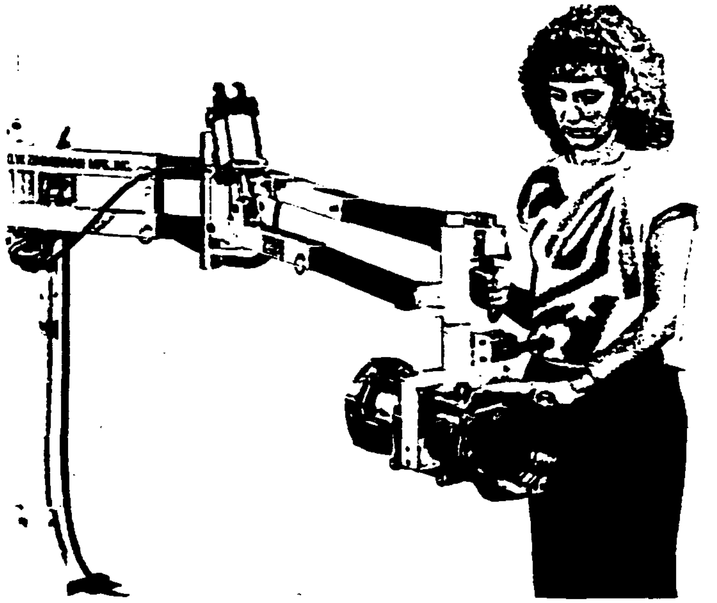
Carriage-mounted Series 700C Arm System with custom engineered end effector for wire spool handling.

Zimmerman Manipulators.

- Ergonomic design
- Operator friendly
- Float action
- Precision positioning
- Various models
- Custom grippers
- Mounting options



Pedestal-mounted Series 700C Arm System with custom engineered end effector for projectile handling.



Pedestal-mounted Series 400 Manipulator utilizes custom clamping end effector for handling transmissions.

Providing innovative material handling solutions for three decades.

D.W. ZIMMERMAN MFG., INC.
29555-T STEPHENSON HIGHWAY
MADISON HEIGHTS, MI 48071-2387
(313) 398-6200
FAX: (313) 398-1374